MODERN PLASTICS

mp

FEBRUARY 1944

DESIGN DATA ON PLASTICS

FROM THE DUREZ LABORATORIES

II. COST FACTORS

The basis for good design in plastics is not unlike that for any other material. Attention must be given to the fundamentals involved in the benefits of one plastic material over another, molding and finishing needs, and the cost of the finished product.

The subject of costs emphasizes the importance of working closely with your custom molder. Bring him into the picture early. His experience can result in substantial economies. There are many instances when he has shown that molding costs were excessive. We know of other occasions when he has helped to eliminate an unnecessary production expense or costly machining operations in the mold.

Good design gives every possible consideration to easy removal of the piece from the mold. Intricate shapes are being molded every day with Durez phenolics, but production costs are reduced whenever a complicated mold is avoided. Split molds, for instance, mean additional press time for assembling and disassembling this mold.

Simplicity saves money. It has been pointed out, however, that the cost of a seemingly complex part may be warranted by a saving in later machining and assembly operations.

Inserts frequently hand the designer a cost problem. Generally speaking, the inclusion of inserts in the molding operation will prove an advantage. Though molding costs are high, they too are offset by time and labor savings in final assembly.

If possible, design should provide for making projecting inserts round. When odd shapes are tooled in the mold, additional costs are usually involved.

As a suggestion, your molder may have a selection of well designed inserts which are produced in such volume that they can be used most economically.

There are times when tolerances are called for which are closer than actually needed. These tolerances can be furnished but they add to costs by slowing production. And the more leeway given the mold maker, the less expensive the mold.

In cases of extremely exacting tolerances it may prove better to mold slightly oversize and then machine to the required specification.

Good design seeks to eliminate undercuts. They mean additional mold costs and slower production. There have been recent developments in molding with Durez phenolics which have answered some of the problems. The designer does not have to be restricted if undercuts are essential.

Fillets are another interesting cost factor. Though they are used to facilitate flow and build up structural strength, they often serve to simplify mold construction. In such cases a less costly mold is achieved.

Here, we can give only a few of the cost factors in plastic design. A major consideration in the popularity of Durez phenolics is their low cost advantage. When this advantage is added to their moldability which makes them easier to use, and the broad scope of their properties through a wide range of temperatures, you can see why we suggest that you give careful consideration to Durez phenolics. We welcome the opportunity to work with you on any plastic material problem. And a member of our technical staff will be glad to assist you with additional data. Durez Plastics & Chemicals, Inc., 52 Walck Road, North Tonawanda, N. Y.

DUREZ

PHENOLIC MOLDING COMPOUNDS AND RESINS

PLASTICS THAT FIT THE JOB


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Catalin
Today, Catalin's unmatched powers of expressing gem-like color and beauty mean little. Of prime importance are its mechanical, thermal and chemical properties . . . its physical characteristics and working qualities.
But the day is to come when beauty will again enjoy freedom of expression. Preparation for the surge that will mount with peace should have its beginning now. For example, Charles Leslie Fordyce presents here his idea for an exquisite brush back conceived in Catalin. And there are thousands of other inspirations arising in fertile minds that can at least be extended to paper planning.
The assistance of the Catalin staff is readied for just such constructive thinking. Complete information on Catalin Cast Resins—and on Loalin Polystyrene molding compounds is available. Your inquiry is invited.
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CAST RESINS • MOLDING COMPOUNDS
LIQUID RESINS

MODERN PLASTICS

INCLUDING PLASTICS · PLASTIC PRODUCTS

AND PLASTICS ENGINEERING

★ All editorial contents having bearing on military subjects have been released for publication in MODERN PLASTICS by the Armed Services.

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VOLUME 21 · FEBRUARY 1944 · NUMBER 6

General Interest

Plastics Engineering

Technical Section

News and Features

How do temperature changes affect linear thermal expansion of Du Pont "Lucite"?

More data on Du Pont "Lucite" methyl methacrylate resin sheeting for aircraft designers, engineers and their established enclosure suppliers.

IT IS IMPORTANT that allowance be made for thermal expansion and contraction of plastic airplane enclosures subjected to wide changes in temperature due to altitude and geographical location.

The coefficient of thermal expansion of "Lucite" differs so widely from those of metals commonly used in mounting structures that suitable adjustment of design is necessary. For instance, the linear thermal expansion of "Lucite" is 3 times that of aluminum . . . 8 times that of steel . . . and 10 times that of glass. A differential expansion of as much as 0.006 inch per linear inch may occur in the plastic at the extremes of temperature experienced by military aircraft. See graph and table (Fig. 1) for values of increase and decrease in length of cast "Lucite" bars over the temperature range of −80°C. to +75°C.

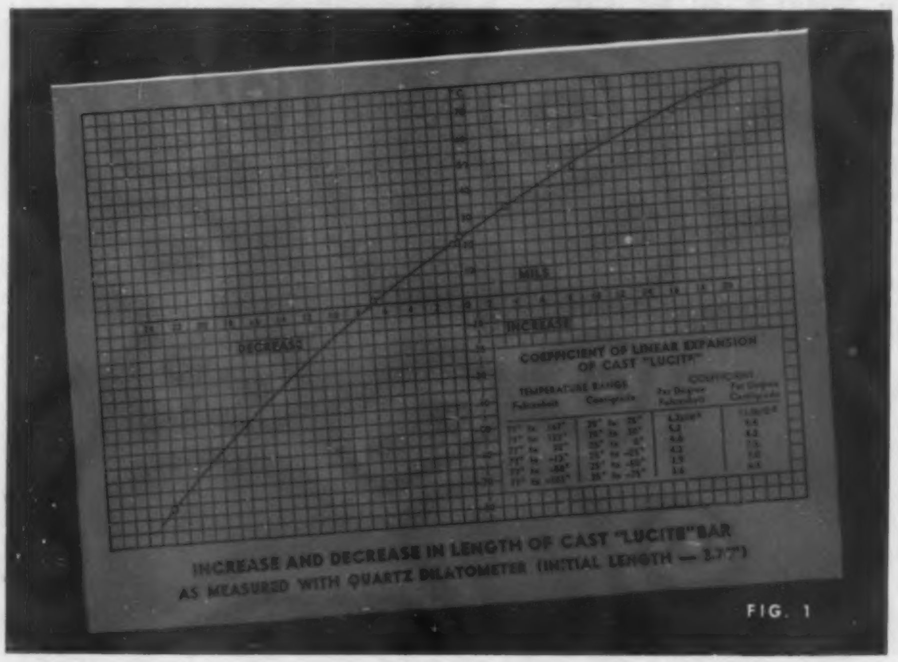

FIG. 1

FIG. 2

METHOD OF MEASURING THERMAL CHANGE OF "LUCITE"

Du Pont technicians measured temperature effects on the length of "Lucite" using a quartz dilatometer, consisting of a 24-inch vertical tube of fused quartz, of 1/16 inch i.d., closed at its lower end (Fig. 2). A sample of "Lucite" 3.74 inches long was placed in the tube, followed by a rod of fused quartz. The rod rested on the sample and transmitted changes in the length of the test bar to a dial gauge.

The lower end of the apparatus was placed in a container of liquid. Expansion and contraction measurements were obtained by heating the liquid electrically, and cooling with "dry ice." Results of tests applying this method of measurement were used to construct the curve of the graph (Fig. 1).

SEE THIS MANUAL FOR MORE DATA

Due to the linear thermal expansion of "Lucite," proper methods of mounting and installing enclosures of the plastic are very important. The 114-page aircraft Manual on "Lucite" includes detailed information on this subject . . . also on fabricating, forming, repairing and general properties of "Lucite." Get your *free* copy. Write on your business letterhead to E. I. du Pont de Nemours & Co. (Inc.), Plastics Department-R, Arlington, N. J., or 5801 South Broadway, Los Angeles.

DU PONT
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"LUCITE"
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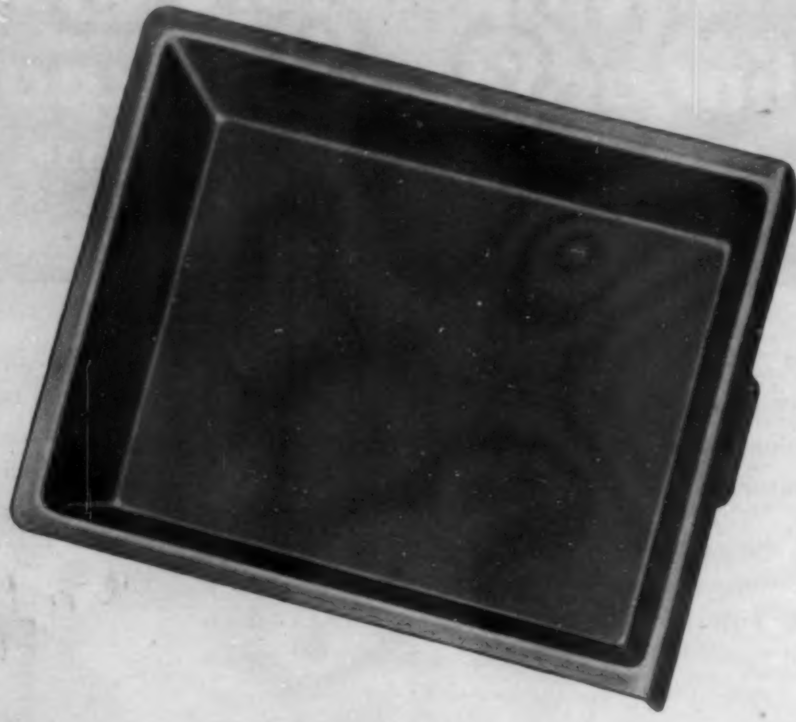
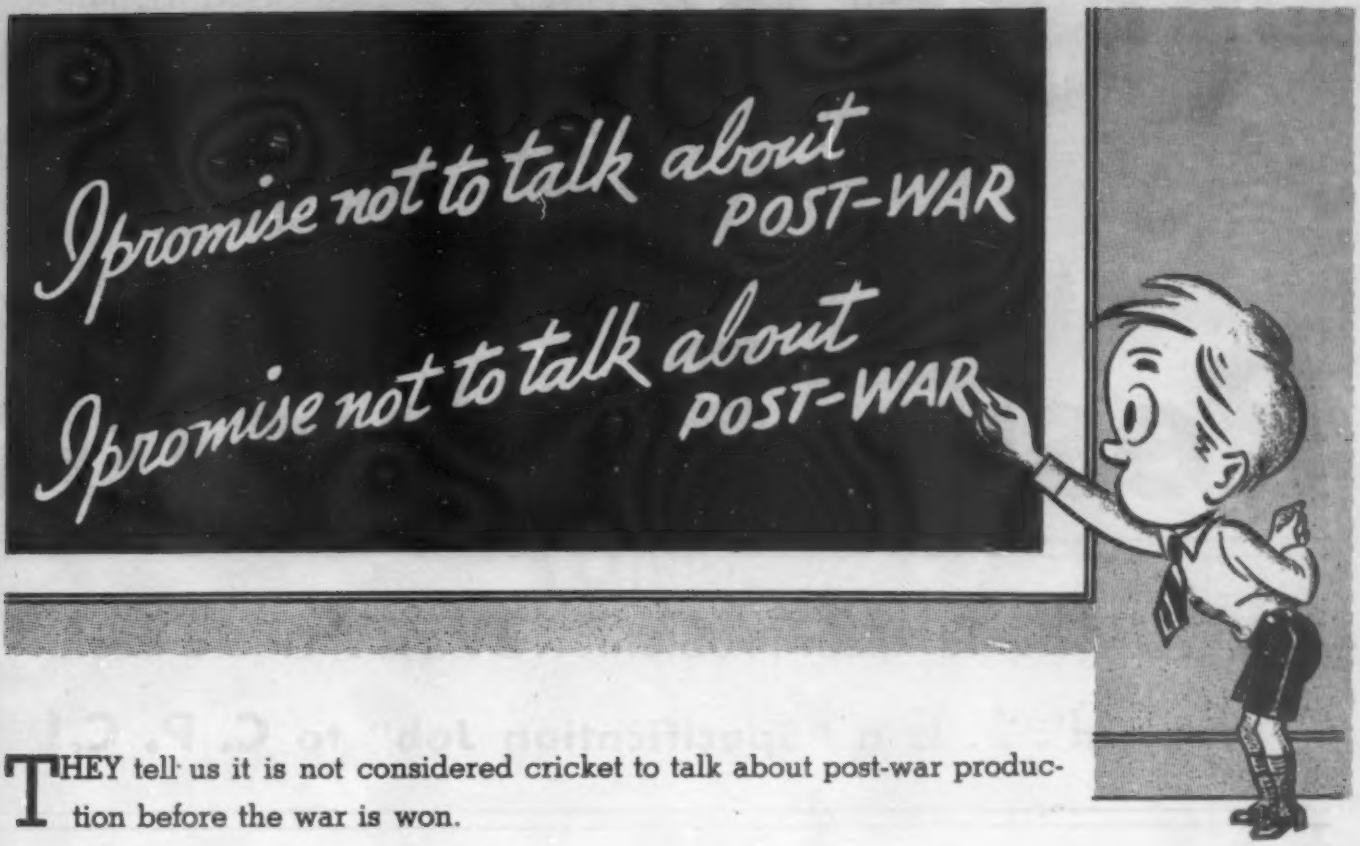
METHYL METHACRYLATE RESIN

Better Things for Better Living . . . *Through Chemistry*





THEY tell us it is not considered cricket to talk about post-war production before the war is won.

We demur. We even disagree.

We have been molding war parts in plastics for many, many months.

Some of them have been developed here, others merely produced to pre-set specs.

Yet we feel that we would be doing our country and our customers and our business a disservice if we did not look forward to reconversion.

We feel that planning can be started now without detracting one iota from war production. In fact, we know it can. We're doing it.

"A Ready Reference for Plastics" written for the layman, is now in its seventh edition. If you are a user or a potential user of molded plastics, write us on your letterhead for a copy of this plain non-technical explanation of their uses and characteristics. Free to business firms and government services.

ARMY E NAVY

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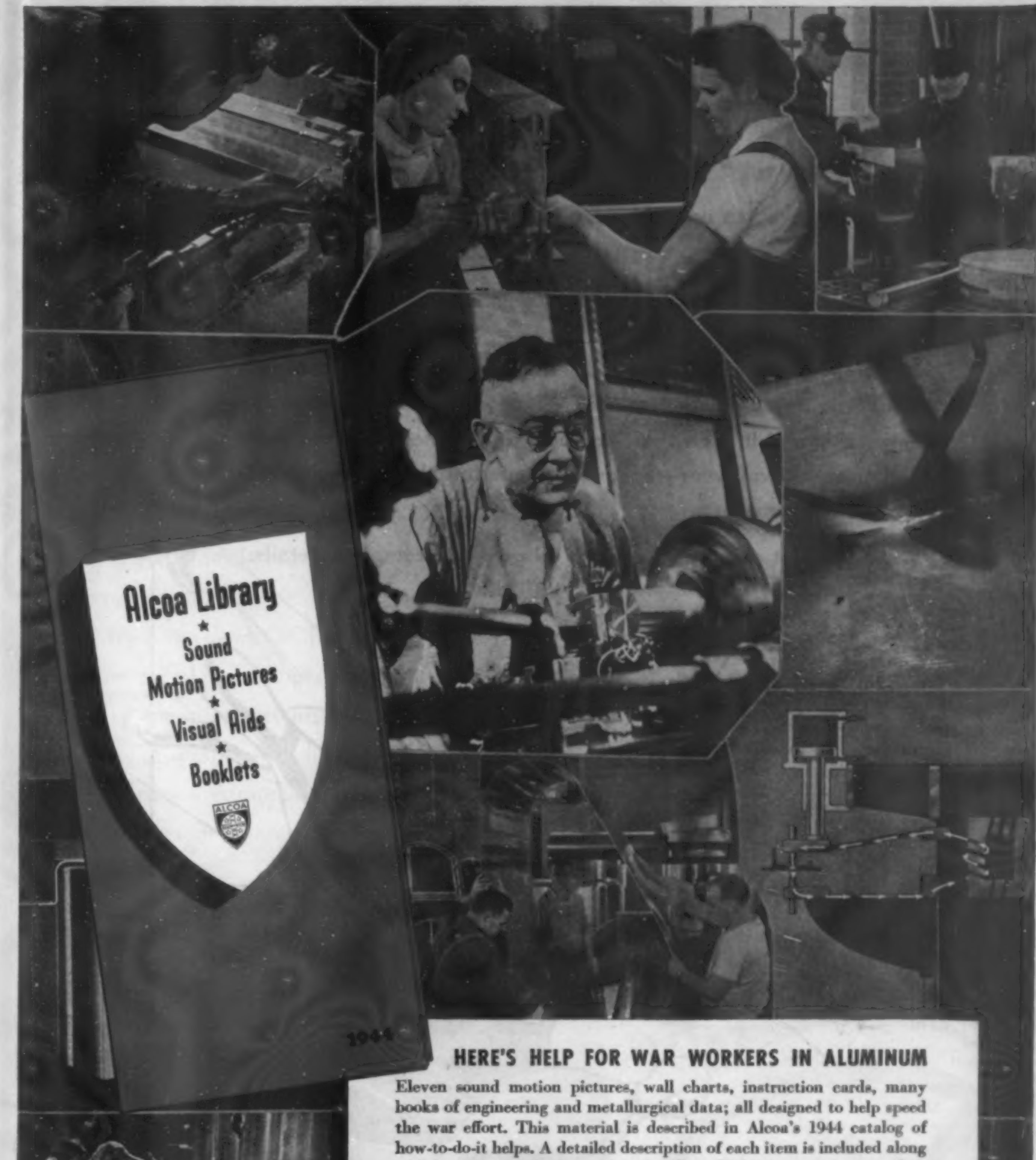
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HERE'S HELP FOR WAR WORKERS IN ALUMINUM
Eleven sound motion pictures, wall charts, instruction cards, many books of engineering and metallurgical data; all designed to help speed the war effort. This material is described in Alcoa's 1944 catalog of how-to-do-it helps. A detailed description of each item is included along with instructions for borrowing the films. Write for your copy today. Aluminum Company of America, 2175 Gulf Building, Pittsburgh, Pa.

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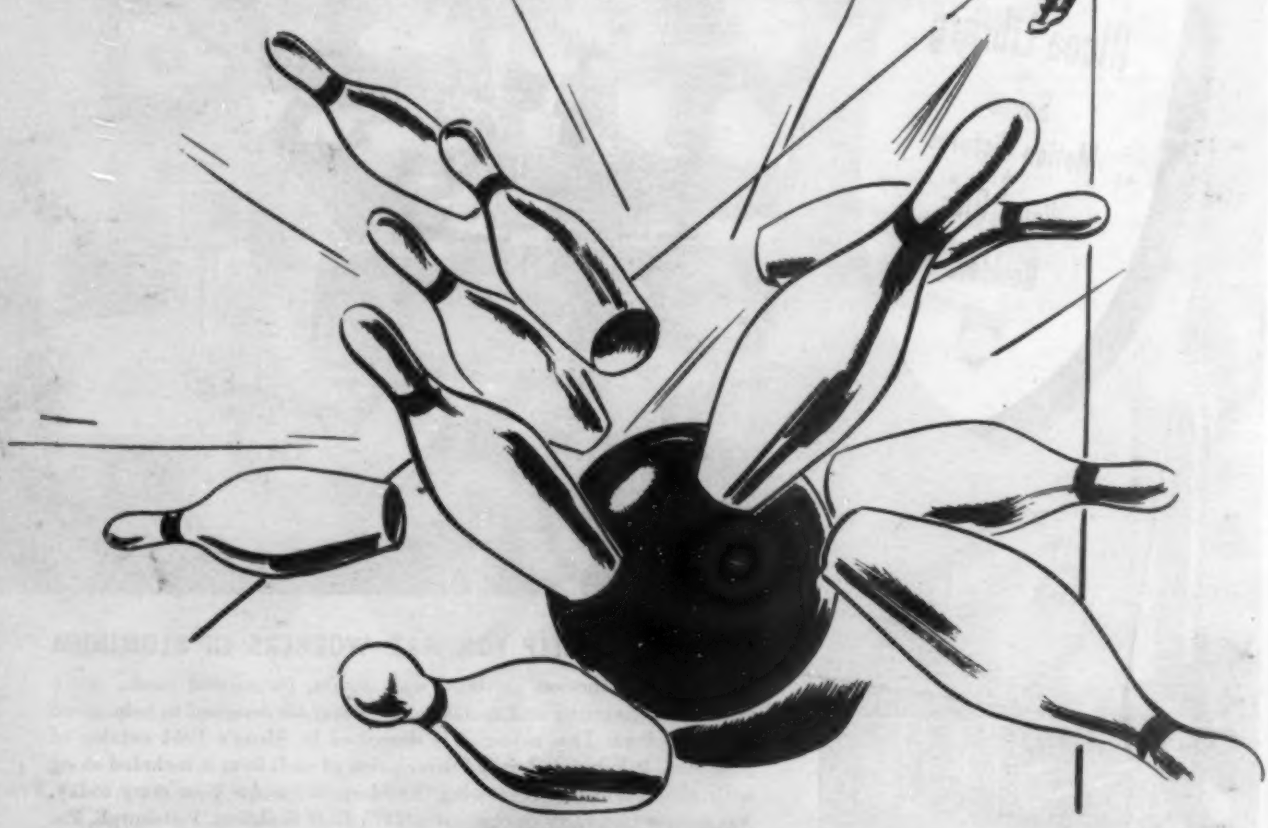
The Bowler's Skill Is Also The Plater's Skill!

"In the Groove" to us, however, is the know-how of getting a highly polished, wear-proof surface of chrome plating down into the grooves, channels and undercuts of the most intricately designed dies.

Just the right delivery... and in just the right places—for Industrial Hard Chrome's methods reach every nook and corner—spots ordinarily skipped! It is on these contours and in these grooves that plating care saves wear—makes the die perform better—multiplies production—cuts costs.

When you get a chance we'd like to give you complete details.



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"Armorplate for Industry"

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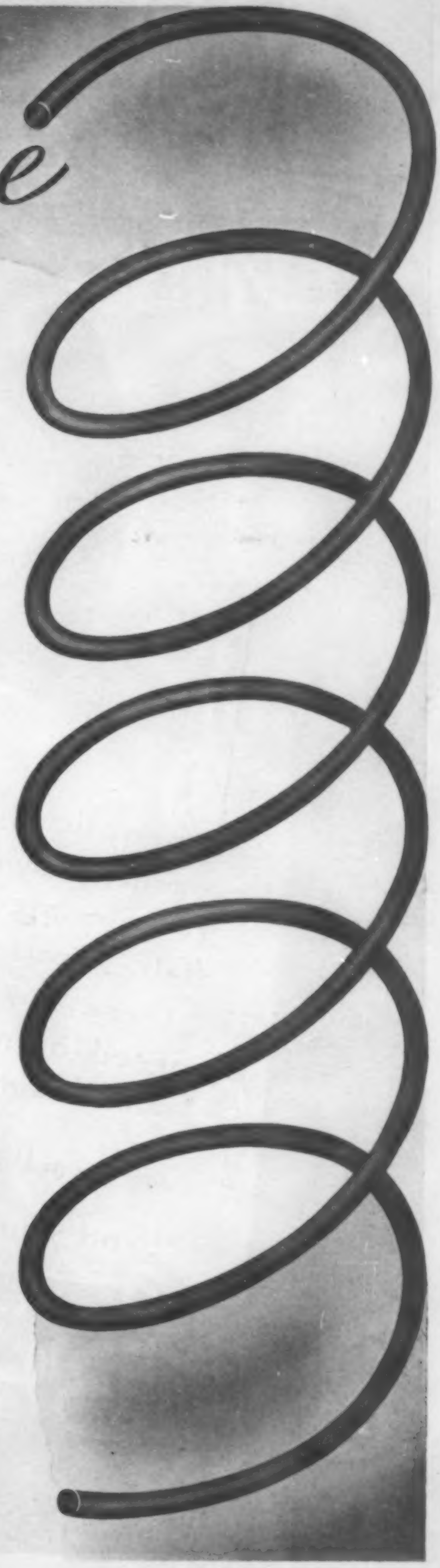

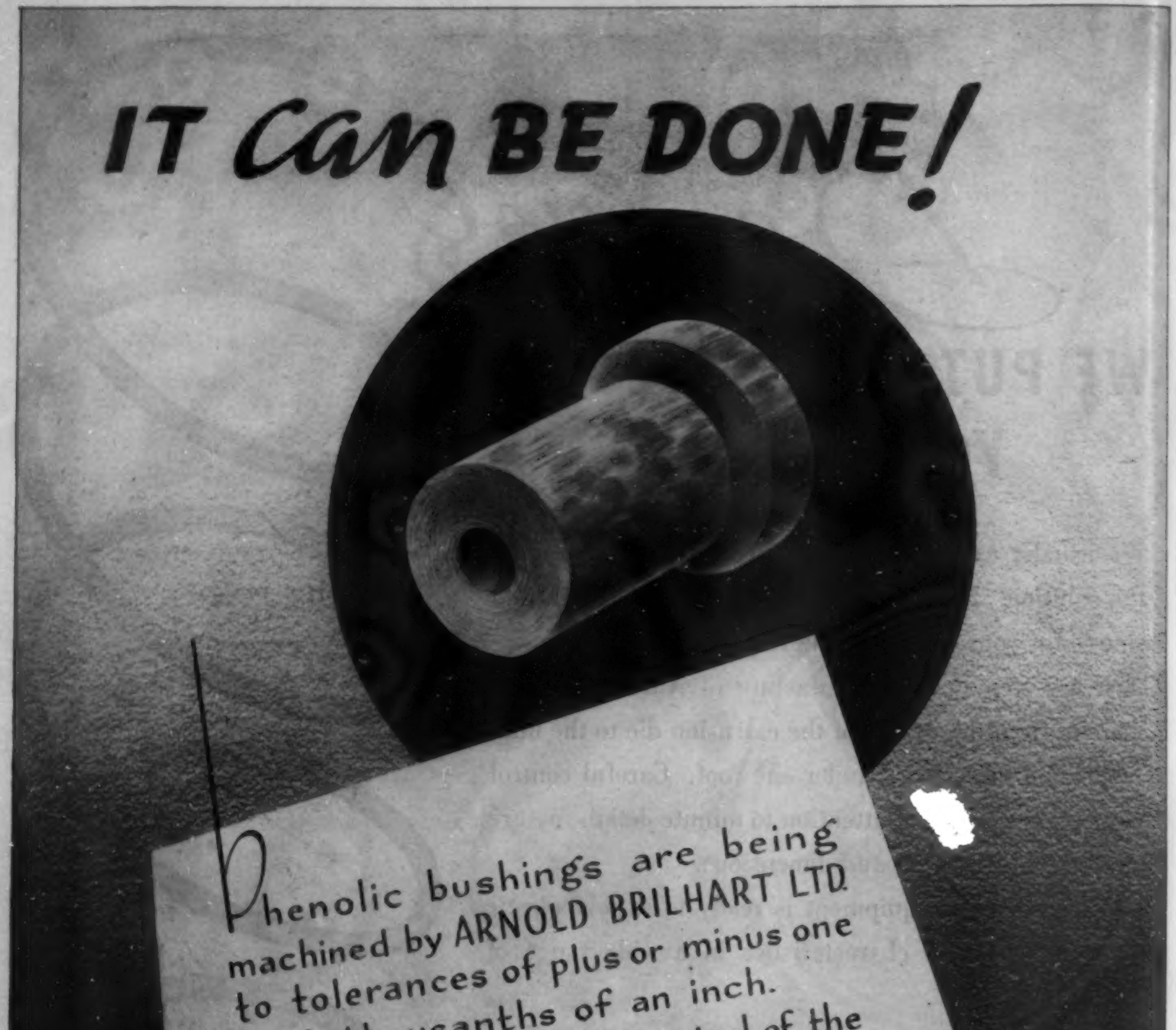
IT Can BE DONE!
Phenolic bushings are being machined by ARNOLD BRILHART LTD. to tolerances of plus or minus one half thousanths of an inch. These bushings are typical of the precision machining being done on both simple and intricate parts.
Just another of the "Impossible things proven possible!"
Send your plastic problems to–
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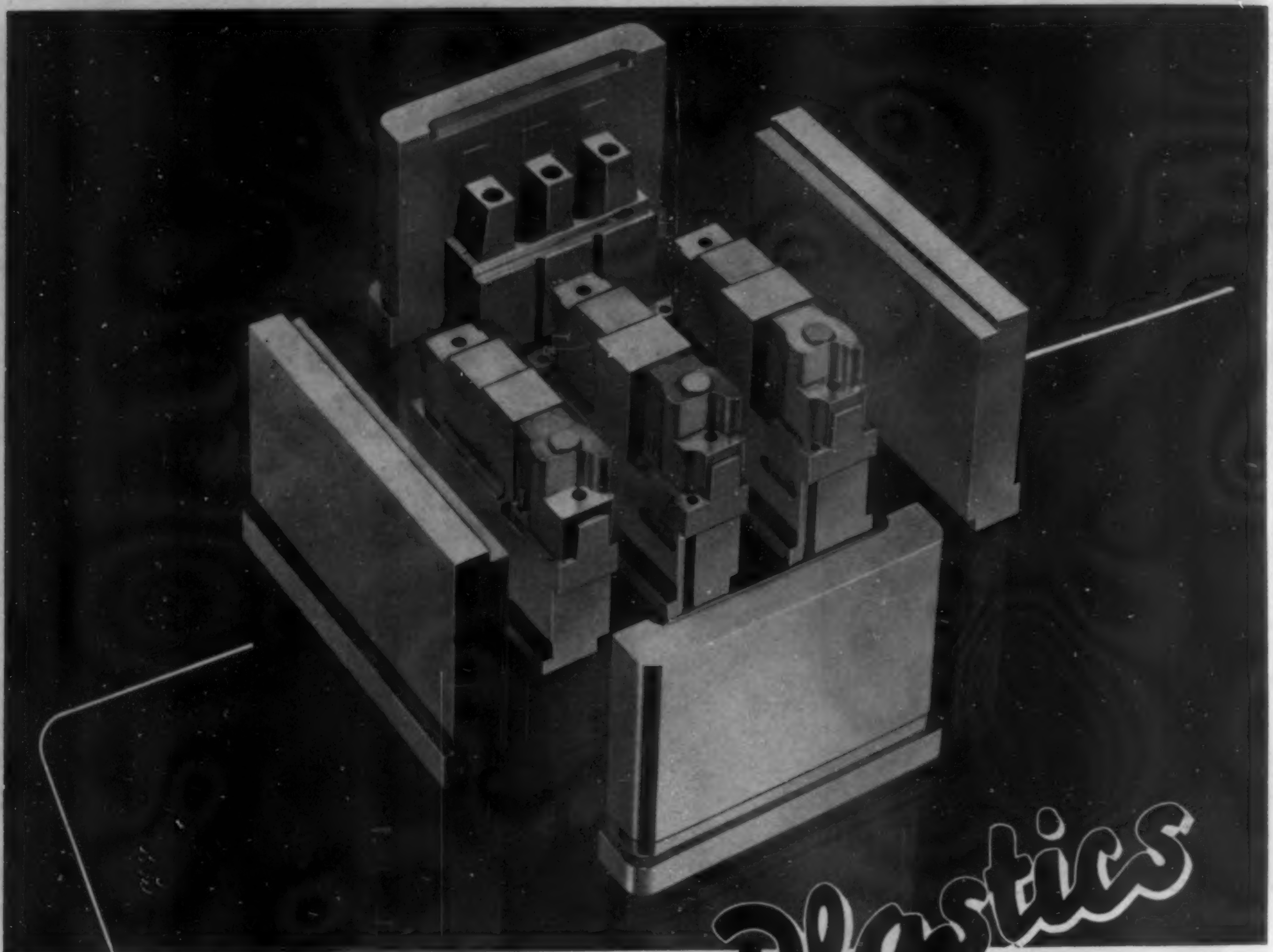
Radios, window frames, batteries, machine parts and wheels were all made from this fibrous plastic material before the war. Most of the machining operations necessary in finishing metal are eliminated, and the savings quickly amortize new mold costs. KYS-ITE'S abrasion resistance, durability, impact and dielectric strength, lustrous finish, wide range of colors and light weight make it unique among plastics.

KEYES
MOLDED PRODUCTS

KEYES MOLDED PRODUCTS . . . As completed essential war contracts release our manufacturing facilities we will again have these trays available, as well as other KYS-ITE products made to your specifications. The wait may not be long, and production is being scheduled as orders are placed. May we suggest you contact us promptly?

Keyes Fibre Company, 420 Lexington Ave. New York 17, N. Y. • *Plant at Waterville, Me.*

BUY WAR BONDS NOW!



Plastic Packaging

REPUTATION BUILT ON ACCOMPLISHMENT

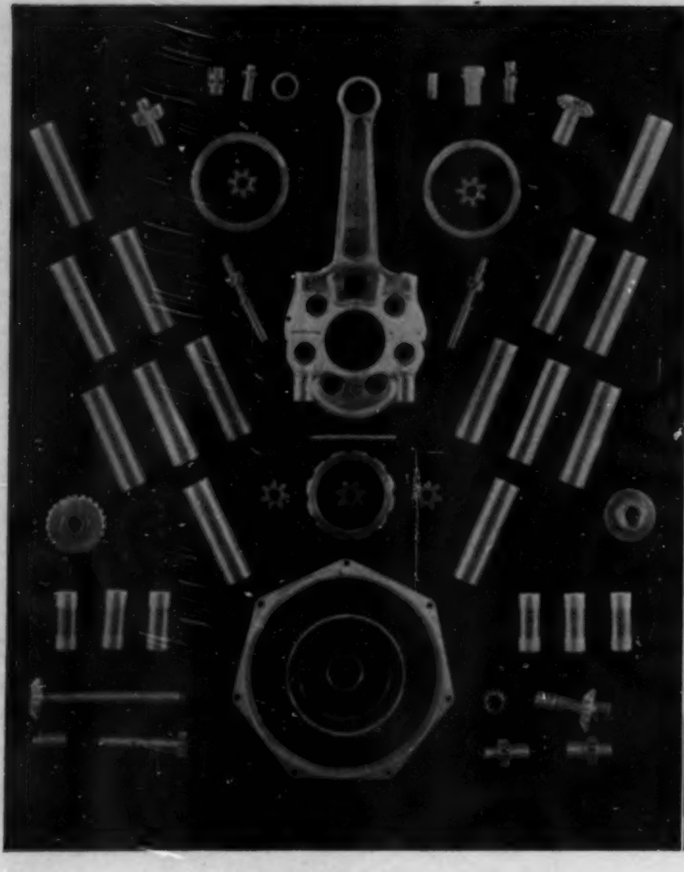
Owens-Illinois is proud of its reputation for producing a host of outstanding packages.

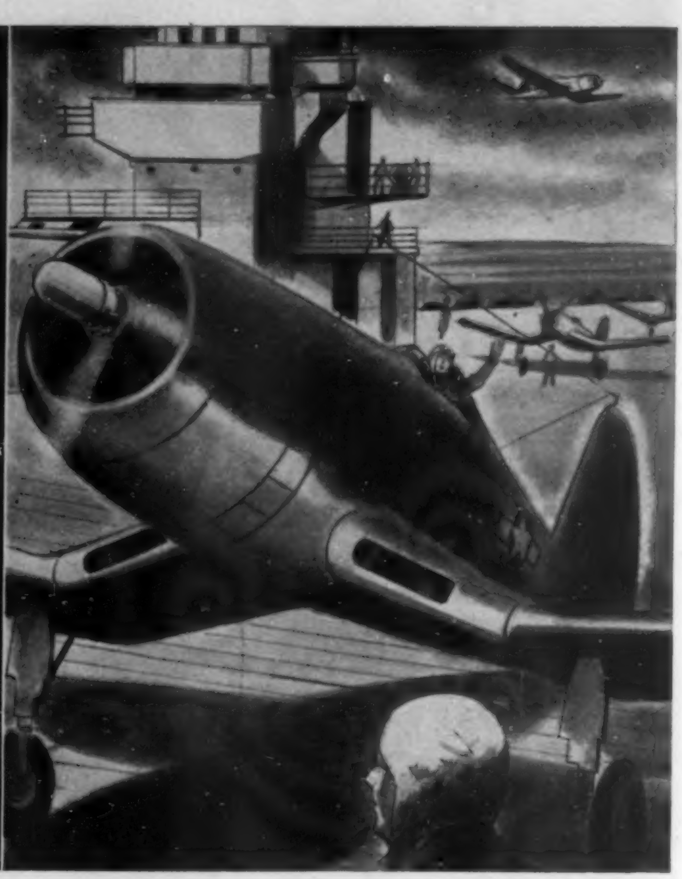
In like manner, peacetime plastic accomplishments —ranging from luxury products to intricate industrial items—point up the versatility of Owens-Illinois plastic engineers. Wartime production is expanding our capabilities in plastics.

In the post-war period, when the word "new" will be extremely important to merchandising plans, our plastic ideas—measuring up to an ingenious packaging reputation, reflecting a broad plastic experience—will be yours.

Custom Molding

OWENS-ILLINOIS
Plastics Division
TOLEDO, OHIO





Together They Spell V-I-C-T-O-R-Y

LOOK OVER THE EDGE of a carrier's flat top, or stand on the side of a jungle clearing when the incisive, urgent demand to *"Scramble!"* sends the world's finest pilots into the cockpits of Corsairs, Hellcats, or Thunderbolts. You'll understand why it goes without saying that every pilot appreciates the mechanical marvels of these battle planes. Catch that grim, yet confident smile that touches their lips as they "pour on the coal" and "rev" up their 2000 horsepower Wasps. It's the acid test. And as those daredevil kids hit the blue with a nonchalant flip of the mitt, you feel that the greatest support to their courage is their confidence in the caliber of craftsmanship which made the power plants in their planes possible.

An aircraft engine manufacturer must be master of the infinite. Exquisite precision in all manufacturing and assembly operations must ever be his goal—for the challenge in making an engine like the 2000 horsepower Double Wasp is this . . . to preserve . . . by delicate accuracy of manufacture and finish . . . all of the inherent strength and endurance in every ounce of material used. This need for perfection is not new to McAleer. For years it has been our special province to develop materials and methods for finishing metals with precision and lapidarian skill. In today's tasks we are benefitted by 18 years of manufacturing experience in the development of *quality-controlled* finishing materials and job-proven finishing methods. These facilities we gladly place at your disposal.

Your war-time finishing problem may not be as tough as that presented by the finishing requirements of the above aircraft engine parts where the micron finish had to meet the toughest of Army and Navy specifications—then again, in its own way, depending on the job to be done, whether that job involved the polishing or buffing of aluminum, brass, steel, copper, nickel, chrome and other metals, or even plastics—it may be tougher to lick. In any event if it's got you stumped—we'd like a try at it. We'll let results speak for themselves! It is our privilege to continue to work closely with many of America's leading War Materiel producers—they, you and we have but one job to do until victory is won. *Let's get on with it!*

To McAleer, a plastic is but another type of metal and our 18 years of industrial finishing "know-how" has been extended to the Plastics Industry ever since its inception. For practical job-proven advice on the finishing of any or all of the base-plastics below, consult McAleer's Plastic Finishing Division.

PHENOL-FORMALDEHYDES • UREA-FORMALDEHYDES • ACRYLATES and METHACRYLATES • STYRENES • HARD RUBBERS
CASEINS • ETHYL-CELLULOSES • CELLULOSE ACETATES • CELLULOSE ACETATE BUTYRATES • CELLULOSE NITRATES

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MANUFACTURING CO.

Manufacturers of Quality Controlled Finishing Materials

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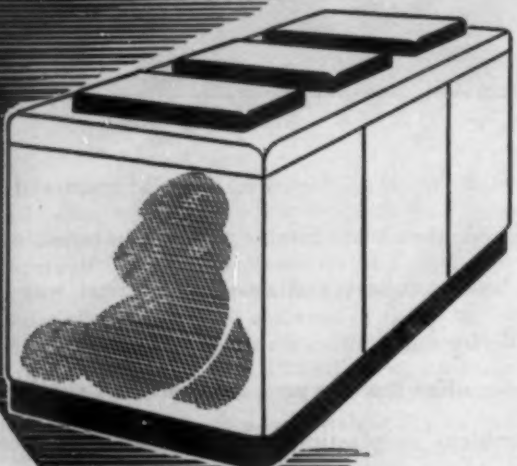
Today

Tomorrow



Paper base plastics compete with metals and powder moldings in about the same way bananas compete with apples. There is no direct comparison.

With Riegel X a new, different material is made, having distinct characteristics and functions. It opens up new revolutionary fields for plastics, particularly in large area molded forms where strength is a requirement.

A plastic that is used today in an airplane wing tip or ammunition box, has a hundred civilian applications tomorrow. Frozen food cabinets, for instance, can be lighter in weight with greater thermal and electrical insulation, and can be produced in large numbers with exceptional accuracy.

Other post-war products that can benefit from the special qualities of Riegel-X will appear on the market soon after restrictions are eased.

Find out now where Riegel-X fits into your post-war plans. Riegel Paper Corporation, 342 Madison Ave., New York 17, N. Y.

RIEGEL-X

X **A group of plain and impregnated base papers for both fluid and direct pressure plastic laminates.** X

98

Molders, Development Engineers, Research Men, Post-War Planners:

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...the New Rope Fibre Plastic

GET ALL THE FACTS about Co-Ro-Lite — the new patented* rope fibre plastic which offers:

1. Impact strength on a par with laminates
2. Wide range of density
3. Wide range of molding shapes
4. Distinctive natural texture
5. Combined rigidity and elasticity in the same piece

We are now preparing a handbook explaining the characteristics and application of this unique plastic to post-war products. Send us your name and address and we will gladly mail you a free copy as soon as this book is printed.

*Patent No. 2,249,888. Other Patents Pending.

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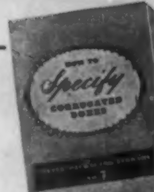
That's a big bomber nose in the corrugated box. It's a mighty important piece of war goods, and its safe delivery stresses the vital role, war-time packaging is playing. Yes, on the unbroken chain of production, packaging and safe arrival depends the welfare of our armed forces.

Techniques developed in the engineering of war-time packages, that carry every type of war supplies to world-wide destinations, are carefully studied by H & D Package Engineers so that every possible packaging improvement will be in readiness for your post-war requirements.

Tomorrow's shipments will profit by today's packaging developments. Now is the time to plan post-war packaging. Rugged, dependable H & D corrugated boxes, designed by the authority on packaging, are the answer to shipshape, undamaged deliveries. Let H & D Package Engineers help you with your plans for post-war packages that protect and promote the product.

IF YOU CAN'T BUY TWO WAR BONDS PER MONTH—BUY ONE!



TELLS HOW TO SPECIFY CORRUGATED BOXES

Information on shipment size, weight, value, packaging, sealing, handling, and a question chart to easily determine the proper corrugated box to use, are clearly outlined in the H & D "Little Packaging Library" booklet, "How To Specify Corrugated Boxes."

This booklet as well as the 7 others that comprise the H & D "Little Packaging Library" can be had by writing The Hinde & Dauch Paper Company, Executive Offices, 4475 Decatur Street, Sandusky, Ohio.

FACTORIES in Baltimore • Boston • Buffalo Chicago • Cleveland • Detroit • Gloucester, N. J. Hoboken • Kansas City • Lenoir, N. C. • Montreal Richmond • St. Louis • Sandusky, Ohio • Toronto

For postwar packaging.. better see **HINDE & DAUCH**

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Tilting Head Press
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ready for installation
Pressures to
3000 p. s. i.

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Their color is permanent. They are non-reactive, non-bleeding and non-toxic. They have high tinctorial value, fine particle size, and are easy to process.
• COLOR BLACKS
are available in powder form and in beads. Five grades covering the color span now are being used successfully in the making of plastics of all types.
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include four basic colors in fifteen pleasing shades. By mixing colors or extending them with white, an unlimited number of warm, rich tints can be produced.
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BEAD CHAIN MULTI-SWAGE PROCESS is the economical way to produce small metal parts in volume.

Original tool costs are lower and tool wear is considerably less with MULTI-SWAGE than with other machining processes. Because parts are formed from flat stock, or wire, without waste, scrap is practically eliminated as an item of cost. High speed production with close tolerances is characteristic of the MULTI-SWAGE PROCESS.

If you are planning post-war products using small hollow, or solid round parts, our Research and Development Division will gladly show you the advantage of making them by MULTI-SWAGE.

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PROCESS

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THE MOST ECONOMICAL METHOD OF PRODUCING SMALL METAL PARTS TO CLOSE TOLERANCES WITHOUT WASTE

THE BEAD CHAIN MANUFACTURING COMPANY

MOUNTAIN GROVE AND STATE STS., BRIDGEPORT 5, CONN.


METAPLAST CO. LAB REPORT
JOB NO. 3927 TEST NO. 7
JOB: Copper plated housing cadmium finished
TENSILE STRENGTH OF PLATE: 13,000 psi. Elong 15%
THICKNESS: .003" copper, .0005" cadmium
REMARKS: O.K. for vibration use. O.K. on salt spray corrosion
DATE: Signature: J.R.
Metal Plating on Plastics to SPECIFICATIONS
. . . Thousands of Antenna Masts of copper plated compreg wood for Combat planes
. . . Thousands of Plastic Housings plated with copper and cadmium for our Bombers.
Each and every non-conductive unit meticulously electroplated to meet the usual, rigid, ultimate-in-precision specifications of the Army and Navy. That's the unheralded record of Metaplast and its group of laboratory technicians, chemical engineers, and highly skilled electroplaters.
Metaplast is the accepted precision-tested method for electro-depositing a smooth, non-porous, adhesive, metal coating in any desired thickness on non-conductive surfaces.
May we work with you on your problems. War work or post-war planning are of equal interest to us.
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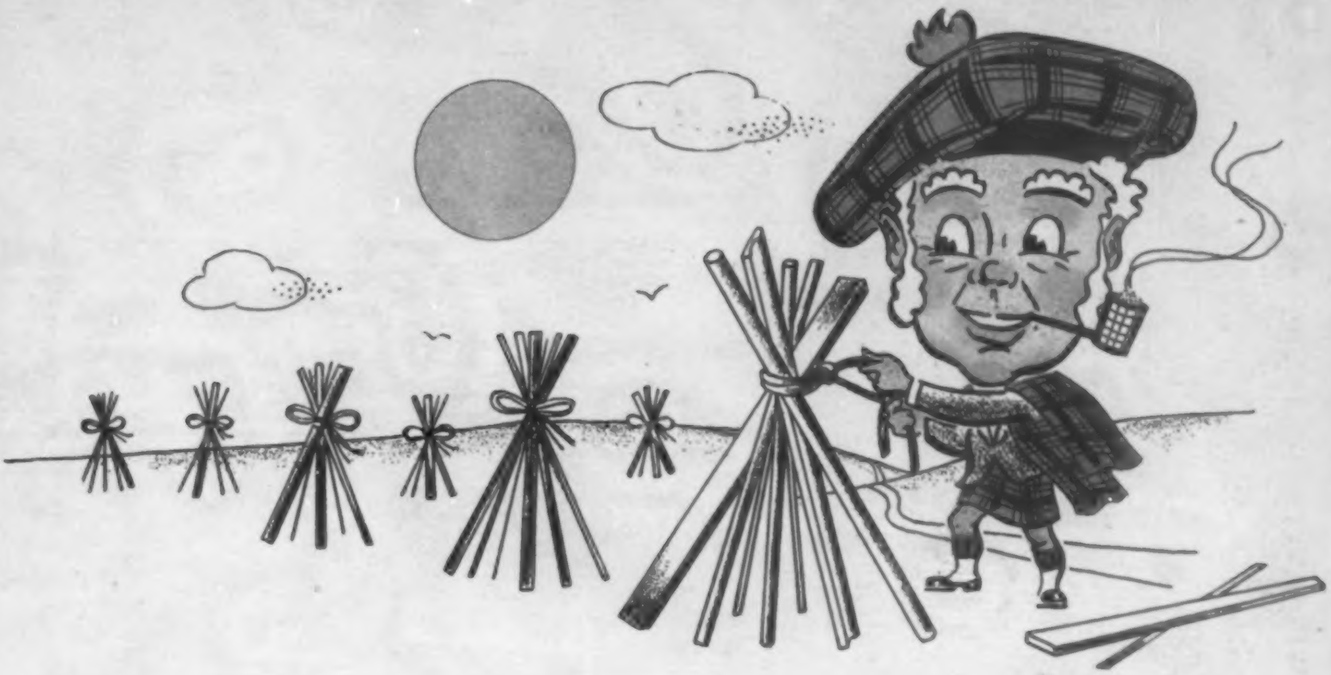
RICH HARVEST OF EXTRUDING IDEAS



WHEN you want precision extrusions for industrial applications in the latest thermoplastic materials, or when you are planning some new application of the extrusion process, you need more than an extrusion machine and some raw plastics.

You need new ideas and you need experience—a combination that enables you to offer plastics extrusion as a potent tool to your designers, engineers and merchandising men.

As the *first* dry extruder—originator of the process—we have been privileged to initiate extrusion applications for many industries: automotive, refrigeration, furniture.

Perhaps we can do the same for you.

We also do injection molding

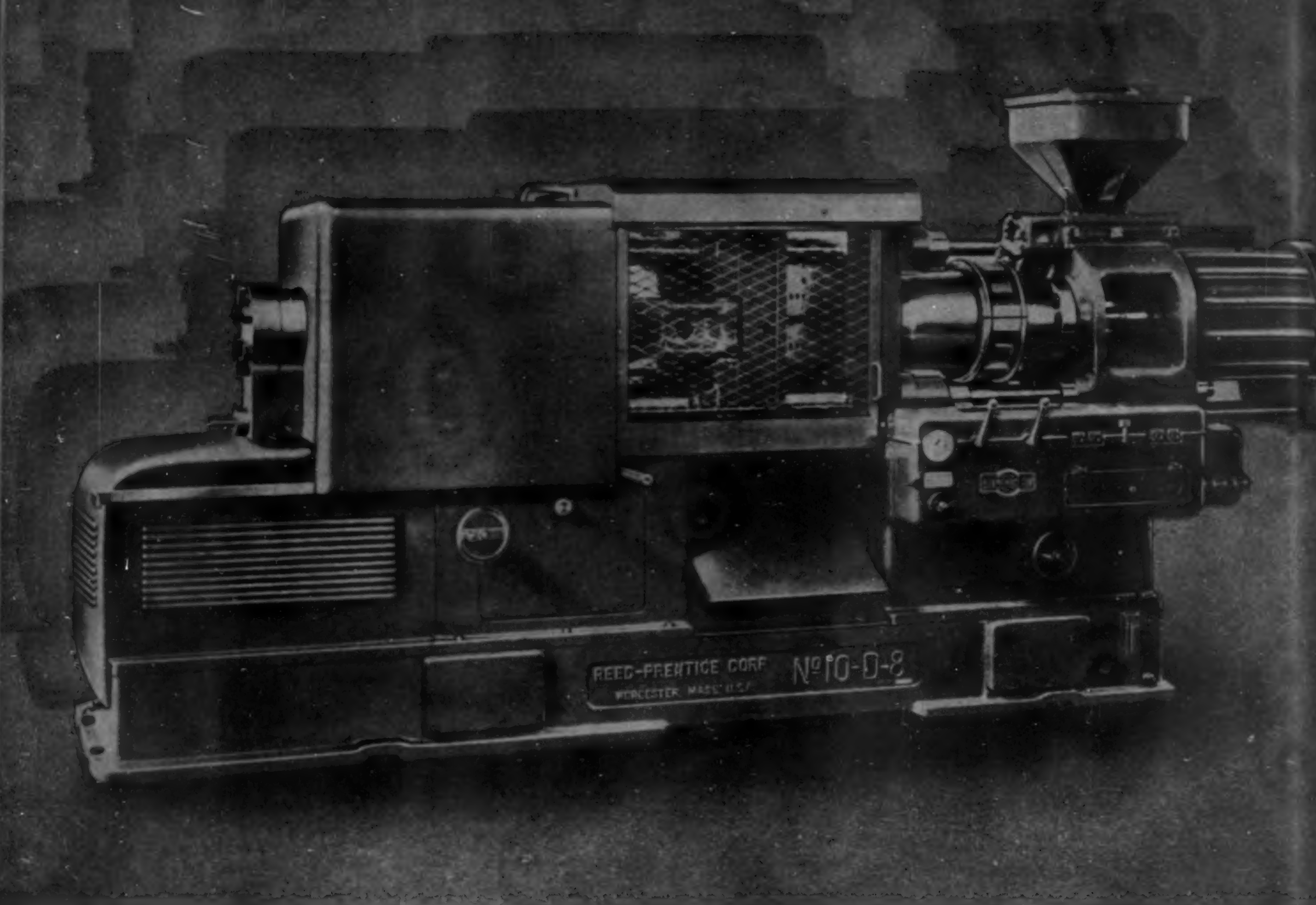
DETROIT MACOID

CORPORATION

12340 Cloverdale Ave. Detroit, Michigan

ORIGINATORS OF DRY PROCESS PLASTIC EXTRUSION

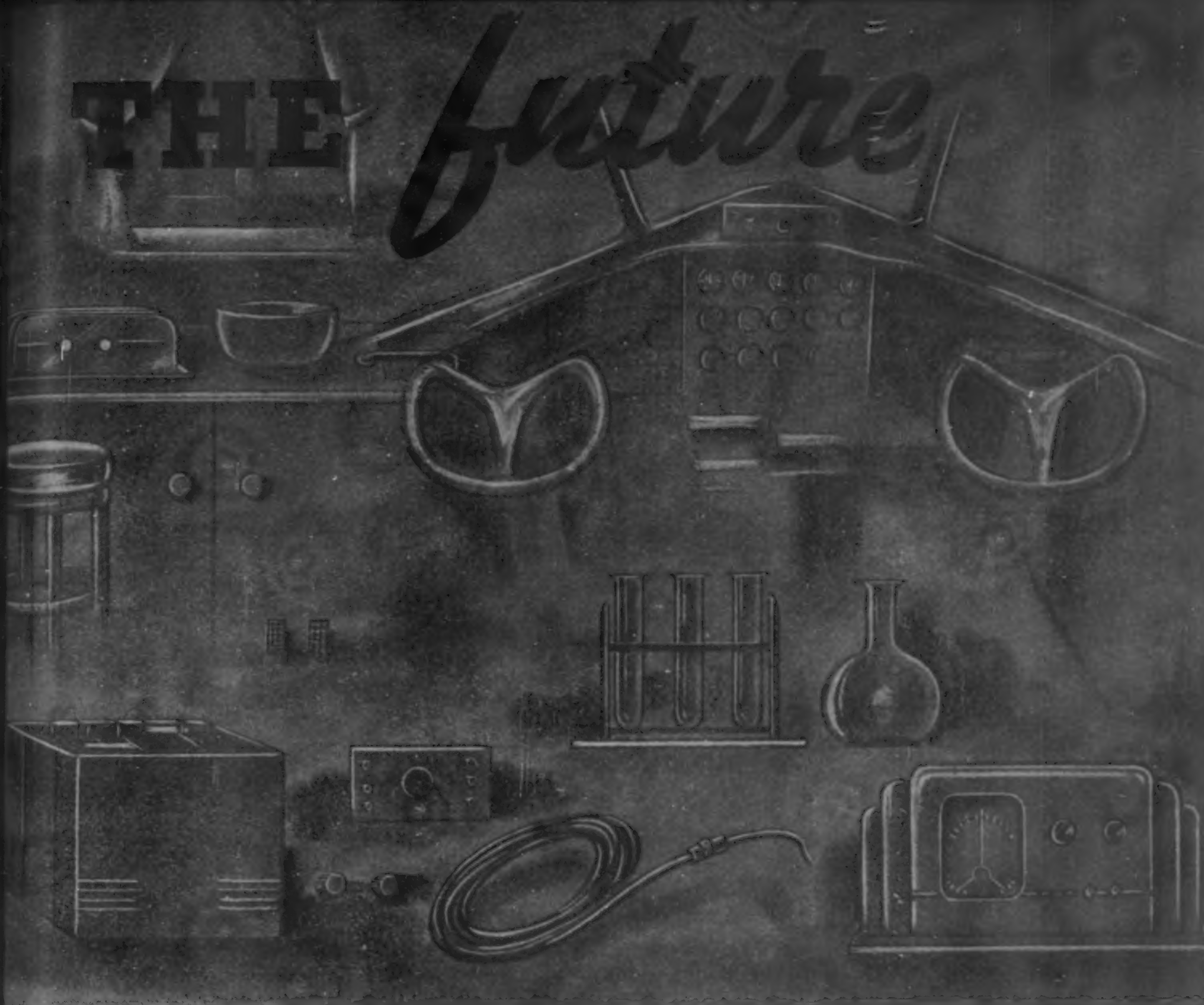
PLASTICS MOLD



AIRCRAFT . . . *AUTOMOTIVE . . .*

Plastics — a magic word that has vitalized the thinking of thousands! Unlimited in scope of design and application, plastics will provide in the future more of the conveniences of living than ever before. Homes will be beautified, automobiles and aircraft will be lighter and safer, industrial tools will be more practical and useful. Color, shape and cost factors will demand this essential material. Ingenuity of plastics use today is only a beginning. The field of plastics application staggers the imagination.

REED-PRENTICE CORP.



HOUSEHOLD . . . LABORATORY . . .

The possibilities of the plastic industry forecast a tremendous but highly competitive business. Those molders who are equipped to produce rapidly and inexpensively will obtain the lion's share of the future market.

Reed-Prentice Plastic Injection Molding Machines have long been the choice of leading molders because of their speed, precision and adaptability. These are the foremost requirements of injection molding, present and future. May we supply you with complete details of Reed-Prentice machines?

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"DIE-FIT" TOLERANCES
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Widest selectivity in file size, shape, cut and speed for every type of work; rigid file back and work table adjustment; all these assure precise *file-broaching* output in important volume!
Investigate the greater production advantages of DoALL Band Filing—telephone your nearest DoALL Sales Office—now!
FREE Skilled engineering service for a time and method study of your filing problem—bring or send work specimens!
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Dust Collectors, Coolant Systems
Grinding Wheels
Cutting Oils
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Gage Instruments
DoALL
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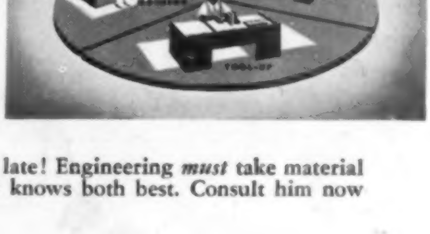
Selecting Your Plastic Molder Calls for Thought—

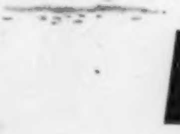
INVESTIGATE CAPACITY!

Plant capacity, we mean. The ability to so integrate engineering, tool-room and die-room, presses and finishing machines . . . and enough of each . . . that plastic parts keep flowing into your production lines on a smooth, uninterrupted schedule.

But plant capacity, important as it is, is only one of the reasons that so many industries come to Kurz-Kasch for so many diverse applications. There's 25 years of experience in engineering plastics . . . in knowing plastic materials as to characteristics and suitability . . . in making intricate molds to the closest tolerances . . . in learning the finest points of the different molding techniques.

Whatever your product, the chances are we can show you interesting applications engineered and molded by Kurz-Kasch that demonstrate the value of this experience to you. And in the most successful ones, you can be sure that our experience with materials and engineering was used to advantage at the *earliest* stages of development. Ask for a Kurz-Kasch development engineer!





Don't contract for capacity too late! Engineering *must* take material into account, and your molder knows both best. Consult him now on your post-war needs.

KURZ-KASCH

For over 25 years Planners and Molders in Plastics

Kurz-Kasch, Inc., 1421 South Broadway, Dayton, Ohio

Branch Sales Offices: New York • Chicago • Detroit • Los Angeles • Dallas • St. Louis • Toronto Canada. *Export Offices:* 89 Broad Street, New York City

Improve Precision with Sav-Way

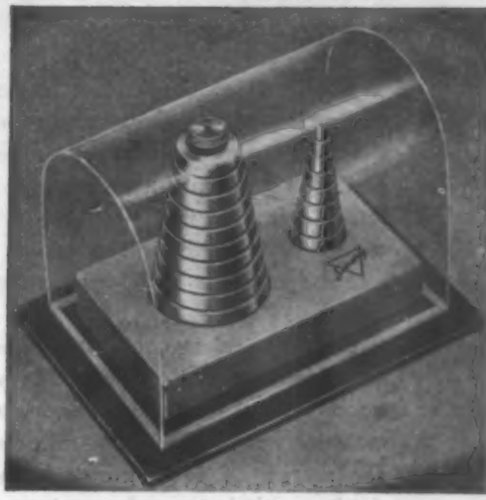
MASTER SETTING AND CHECKING ROLLS

A Really Accurate Method for Checking Micrometers and Other Precision Inspection Devices

Your precision tools and inspection devices are only as accurate as the methods and gages by which they are set and checked. In many cases flat gage blocks are not adequate. This Sav-Way Set of Master Setting and Checking Rolls provides for the first time a really accurate means of checking micrometers, snap gages, amplifiers, and dial indicators.

Eliminates the time wasted in building up combinations of precision gage blocks. Eliminates inaccurate checks caused by uneven wear on micrometer anvils.

When micrometers have been used for some time through one particular part of their range, they may check properly at all other points, and still be inaccurate through the section of greatest wear. Sav-Way Master Checking Rolls provide for 20 quick, accurate checks covering the complete range of the micrometer at one time.



The set consists of 20 rolls ranging from .100" to 2.000" in diameter. The rolls are hardened, ground and lapped to X gage tolerance. Rolls are deep frozen before finish grinding to relieve internal strains and provide accelerated ageing. The set is housed in a modern transparent plastic case.

Sav-Way Industries, Box 117, Harper Station, Detroit 13, Michigan, U. S. A.

Please send illustrated circular describing Sav-Way Master Setting and Checking Rolls.

Name...

Firm...

Address...

City.............................. State..................

Sav-way INDUSTRIES
★ Products Division ★
4875 EAST EIGHT MILE · DETROIT, MICHIGAN

PRODUCERS OF SAV-WAY HAND AND HYDRAULIC INTERNAL GRINDERS · SAV-WAY GOLD SEAL SPINDLES · PLUG GAGES · PRECISION AIRCRAFT AND AUTOMOTIVE PARTS

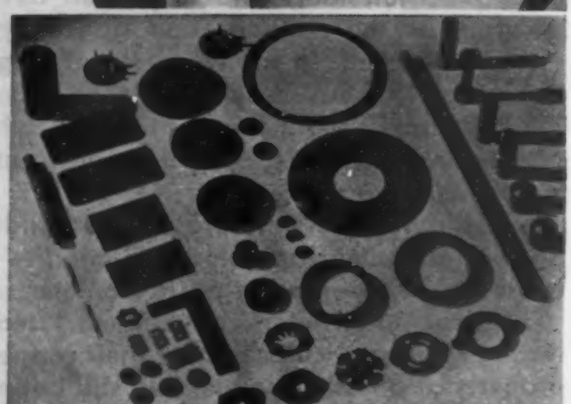
BEHIND all of our modern methods of communication are electrically energized devices. Their successful operation depends on good insulating materials, insulating materials that will take physical abuse and which will function under extreme moisture and temperature conditions.

Ever since electrical energy was first harnessed and put to work C-D materials have provided good insulation. The development of better insulating materials has been the constant goal of the C-D laboratory. The success of C-D's efforts have been the lengthening shadows which have forecast the phenomenal advances which this country has made in the field of communications.

1st DIAMOND Vulcanized FIBRE; then DILECTO, a moisture proof insulation; 3rd VULCOID, which combines to a remarkable degree the desirable properties of both DIAMOND Fibre and DILECTO; 4th MICABOND—Mica insulation in its most usable form and now DILECTENE, a pure resin plastic especially for U-H-F insulation.

C-D engineers have helped solve thousands of insulating problems. They have accumulated a wealth of "know how" which is at your disposal to help solve your electrical insulation problem.

DISTRICT OFFICES: New York • Cleveland • Chicago • Spartanburg, S. C. West Coast Rep., Marwood, Ltd., San Francisco • Sales Offices in principal cities

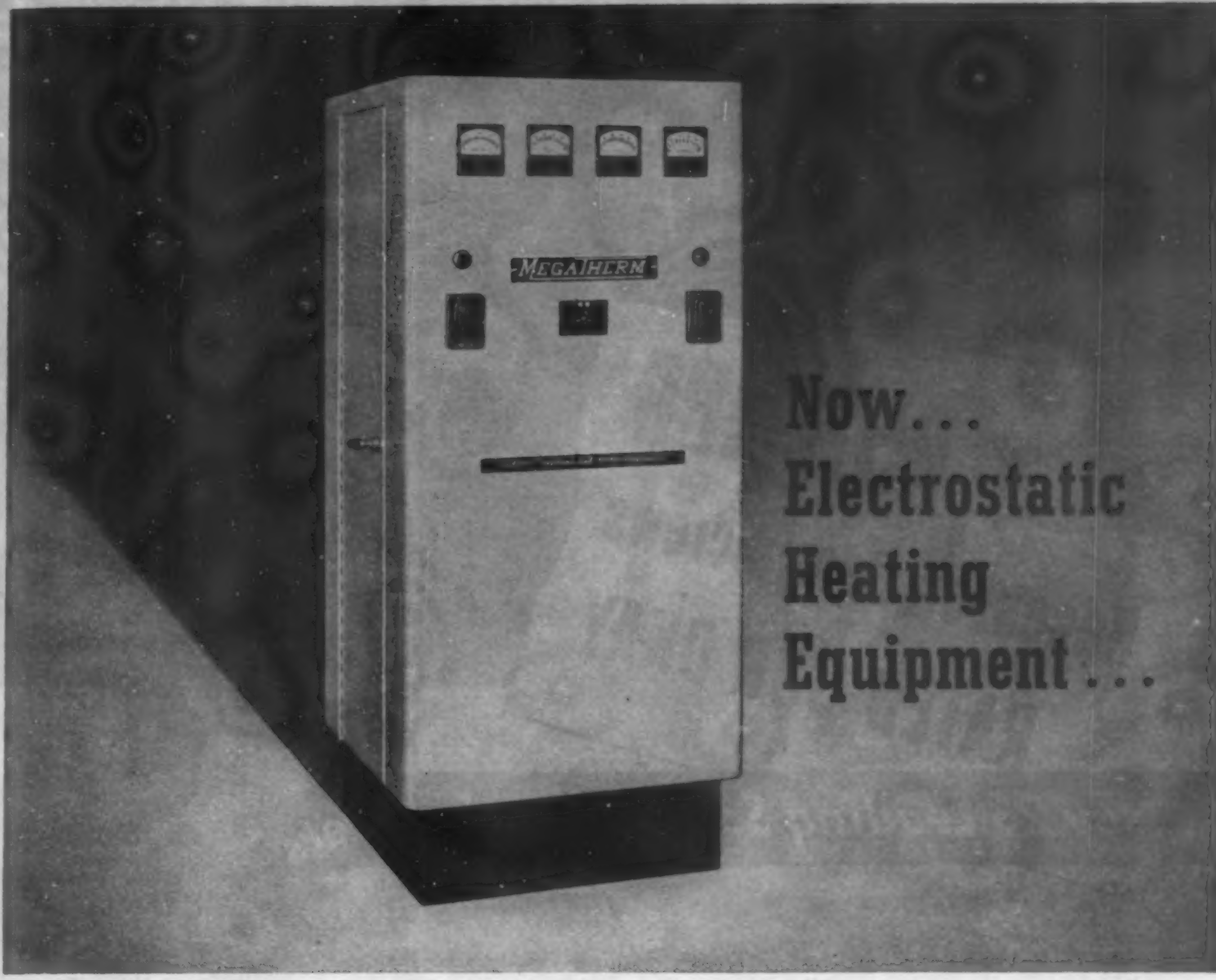


C-D products include THE PLASTICS . . . DILECTO—a laminated phenolic: CELORON—a molded phenolic: DILECTENE—a pure resin plastic especially suited to U-H-F insulation . . . THE NON-METALLICS, DIAMOND Vulcanized Fibre: VULCOID — resin impregnated vulcanized fibre: and MICABOND—built-up mica insulation. Folder GF describes all these products and gives standard sizes and specifications.

CH-43

Continental-Diamond FIBRE COMPANY

Established 1895 . . Manufacturers of Laminated Plastics since 1911 — NEWARK • DELAWARE



...Designed and Built to the Special Requirements of the Plastics Industry

RUGGED
Stands Hard Usage; 1/8" Steel Cabinet

RELIABLE
Gives Efficient, Dependable Service

PORTABLE
Easily Moved for Any Application

COMPACT
All-in-one Unit Saves Floor Space

SIMPLE
Strictly Non-technical in Operation

SPEEDY
Increases Production

ECONOMICAL
Reduces Heating Time and Die Costs

SAFE
Complete Protection for Operator

In pioneering megacycle radio energy for industrial use, Federal has developed an application for Plastics processing that is unique both in conception and performance.

Through its Megatherm equipment it has put radio frequency heating on a practical basis, which assures perfect molding at low pressures, prevents breakage of die inserts, reduces curing time from minutes to seconds and provides uniformity, speed and economy.

Constructed along the same lines as any other machine tool, Megatherm equipment is installed without change in plant layout. It is ready for operation — merely has to be set alongside press and started to work for double or triple production. Simplicity of the unit eliminates tuning or other adjustment. It is controlled by two push buttons, with foot switch optional, and can be operated by unskilled, untrained help.

Megatherm will give you greater production at less cost.

We shall be glad to discuss it with you in terms of your requirements.

-MEGATHERM-

Federal Telephone and Radio Corporation

INDUSTRIAL ELECTRONICS PRODUCT DIVISION, Newark, New Jersey

AN IT&T ASSOCIATE

Only PHILLIPS Recessed Head Screws RATED OUR OKAY

... say 23 Leading Screw Manufacturers

FOR YEARS, leading screw makers tested ideas for recessed heads. All showed design faults. Then came the Phillips Recess. Unanimously, these makers agreed that here, at last, was the answer they'd been looking for . . . a scientifically engineered recess, *right* in every respect.

And practically the entire screw industry adopted it!

There's nothing exactly like the Phillips Recess. It's the only screw recess in which every angle, every dimension has a purpose—plays a definite part in screw driving efficiency and fastening strength.

That's why it pays to specify screws with Phillips Recessed Heads. You can get them in any head style, type, or size.

TO MAKE WARTIME QUOTAS AND PEACETIME PROFITS

FASTER STARTING: Driver point automatically centers in the Phillips Recess . . . fits snugly. Fumbling, wobbly starts, slant driving are eliminated. Work is made trouble-proof for green hands.

FASTER DRIVING: Spiral and power driving are made practical. Driver won't slip from recess to spoil material or injure worker. (Average time saving is 50%.)

EASIER DRIVING: Turning power is fully utilized. Workers maintain speed without tiring.

BETTER FASTENING: Screws are set-up uniformly tight, without burring or breaking of screw heads. The job is stronger, and the ornamental recess adds to appearance.

IDENTIFY IT!

Center corners of Phillips Recess are rounded . . .
NOT square.

Bottom of Phillips Recess is nearly flat . . .
NOT tapered to a sharp point.

AMERICAN SCREW CO.
Providence, Rhode Island
THE BRISTOL CO.
Waterbury, Connecticut
CENTRAL SCREW CO.
Chicago, Illinois
CHANDLER PRODUCTS CORP.
Cleveland, Ohio
CONTINENTAL SCREW CO.
New Bedford, Massachusetts
THE CORBIN SCREW CORP.
New Britain, Connecticut
GENERAL SCREW MFG. CO.
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INTERNATIONAL SCREW CO.
Detroit, Michigan
THE LAMSON & SESSIONS CO.
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MILFORD RIVET AND MACHINE CO.
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PHILLIPS *Recessed Head* SCREWS

WOOD SCREWS
MACHINE SCREWS
SELF-TAPPING SCREWS
STOVE BOLTS

METAL PLATED PLASTICS

● Have you been ruling out plastics because of insufficient tensile strength? There's a surprise in store for you when you give *metal* plated plastics a test.

One aircraft manufacturer reports tensile strength increased 41.3% over that of original unplated molding!

When you consider that the Monroe method of plating plastics with metals also contributes additional flexural strength and impact strength, and assures greater dimensional stability due to increased resistance to heat and cold flow, you will appreciate that metal plated plastics invite your immediate investigation. Control of absorption and corrosion are additional advantages.

Plated plastics also form a perfect electrical shield wherever an application of this type is called for.

Our quarter of a century in production of metal products assures you that we will recommend plated plastics only for applications in which experimentation has proved definite advantages. We will gladly work with your designers and engineers to determine advisability of applications in your specific field.

Write for Information Bulletin No. One on "Plated Plastics".

WHEN YOU THINK OF METAL PLATED PLASTICS, THINK OF—

ARMY E NAVY

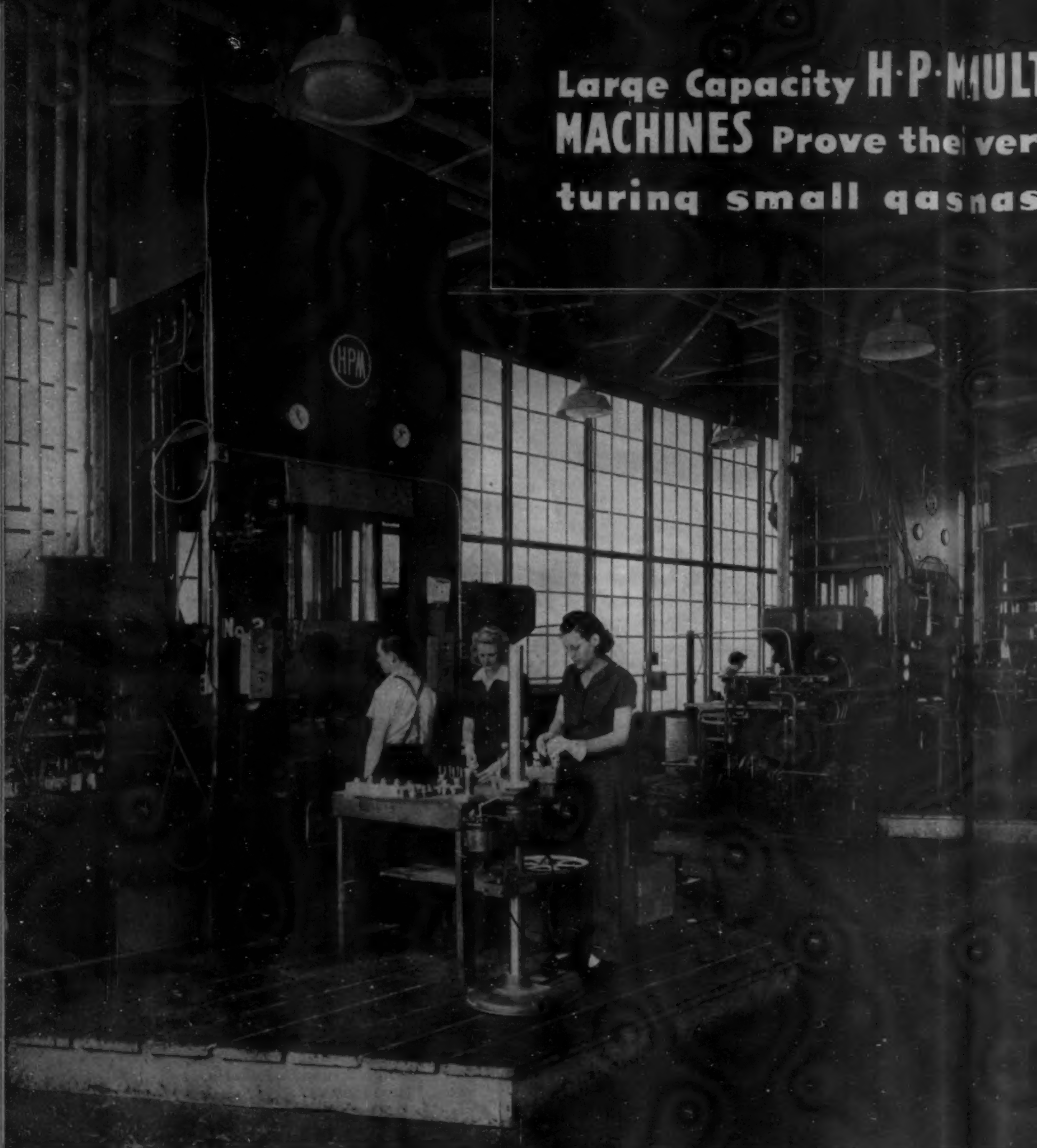
MONROE AUTO EQUIPMENT COMPANY

PLASTICS DIVISION

MONROE, MICH.

The Metaplast Process

Large Capacity H·P·MULT
MACHINES Prove the ver
turing small gasmas



A battery of three H-P-M multi-nozzle injection molding machines installed in the plant of Thermo Plastics Division, Standard Products Company, St. Clair, Michigan.

At right are illustrated the component parts required to make a gas mask assembly. Reading left to right —Plug, seat, body, rubber gasket, diaphragms (cellulose acetate), spacer, retainer, rubber disc, guard, final assembly.

P·MULTIPLE UNIT INJECTION

he versatility in manufac-

asmask parts

These large H-P-M injection machines mold gas mask parts on a mass production basis. Each machine is equipped with four multi-cavity molds, one for each injection unit. Since each mold is served by an independent injection unit, as many as four different colors or kinds of molding material can be used in a single press.

H-P-M plastic molding machines are the accepted standard for difficult molding jobs. The "all-hydraulic" H-P-M design guarantees outstanding press performance. H-P-M HYDRO-POWER radial pumps power each H-P-M molding press. These H-P-M pumps are designed and built for heavy duty hydraulic press service. No other press builder can offer you this undivided responsibility. Choose H-P-M plastic molding presses—gain the experience of the pioneer builder.

THE HYDRAULIC PRESS MFG. CO.
Mount Gilead, Ohio, U. S. A.
District Sales Offices: New York, Syracuse, Detroit, and Chicago. Representatives in Principal Cities.

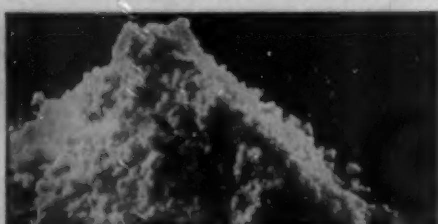
In one press the two rear molds are each designed with four cavities for molding the retainers. The two front molds are each designed with ten cavities for molding the guards. Both guards and retainers are molded with external threads.

In another press the two rear molds are each designed with eight cavities for molding the spacers. The two front molds are each designed with two cavities for molding the bodies. The bodies are molded with internal threads both front and rear.

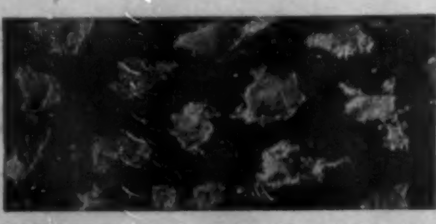
M-52 fuse, in which the requisite extra strength was provided by cotton flock filler.

When Molded Items Need EXTRA STRENGTH

RAYCO-FILLED PLASTICS PROVIDE IT!



FILFLOC Pure cotton flock of surpassing cleanliness and uniformity.



FABRIFIL Macerated cotton fabric for extra strength; uniformity assures good flow

CORDFIL Evenly cut lengths of tire cord; for plastics of utmost strength.

RAYCO Fillers have contributed to the solution of numerous urgent problems demanding extra strength in molded plastics. We invite you to utilize to the fullest extent our experience in adapting cotton fillers to contribute just the right combination of tensile, flexural and impact strength to suit your needs. We work closely with your compound manufacturer—we ourselves are not manufacturers of molding compounds. Our products are FILLERS: Rayco "Filfloc," pure cotton flock for extra strength; Rayco "Fabrifil," macerated fabric for exceptional strength; Rayco "Cordfil," cut lengths of tire cord for maximum strength.

Occasionally we are asked to render cutting service on products outside our line. We are glad to consider such requests.

Insist on compounds containing RAYCO-Fillers—for good flow and maximum strength

RAYON PROCESSING CO. of R.I. INC.

60 TREMONT ST., CENTRAL FALLS, RHODE ISLAND

Developers and Producers of Cotton Fillers for Plastics

CRUVER ANSWERS T

IN PLASTI

1. Weems Aircraft Plotter—Mark II—for aerial navigation. 2. G.I. Machete for carving up jungles and Japs—molded plastic shock-resistant handle. 3. P-38 3-dimensional silhouettes in exact ratios of 1":6'; and miniature-miniature 1":432'. 4. Time: Distance computer for exact flying. 5. Plastic Venturi tube replaces metal, is more accurate & uniform. Withstands weather on outside of plane. 6. True airspeed computer to help bombs to their targets. 7. Handy combination com-

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putes for true airspeed and time: distance. 8. Rim, mouthpiece & handle of megaphone are plastic, replacing brass. 9. Vertical Speed Indicator measures the ups and downs of gliders. Precision in plastics to the nth degree, plus 800% cost-saving. 10. B-17 Flying Fortresses in ratios of 1":6' and 1":432". 11. Precision aircraft Inclinometer replaces glass, eliminates breakage & is more uniform, accurate. 12. Propeller protractor—an all-plastic accurate instrument for heavy field duty.

EXTRUSION EXTRAS!

★ BETTER EQUIPMENT
★ MORE EXPERIENCE
★ FINER CONTROL

Pretty soon, anyone with the price will be able to buy an extruding machine and go into business. But will he, just because he has the equipment, be able to solve your problems on time and at low cost and with satisfactory profiles?

It has taken us a long time to learn what we do know about extrusion and we don't claim to know everything. We're doing some interesting things with the process which we'd like to show you or tell you about. We also combine extrusion with other plastics fabricating processes to achieve unusual articles.

THE GREAT AMERICAN PLASTICS CO.

"Plastics Fabricated by Every Method Known to Industry"

INJECTION · EXTRUDING · COMPRESSION · TRANSFER MOLDING · BLOWING & FORMING · SHEETS · ROD TUBES AND SPECIAL SHAPES

Telephone: Leominster 1650 · LEOMINSTER, MASSACHUSETTS · Teletype Leominster 295

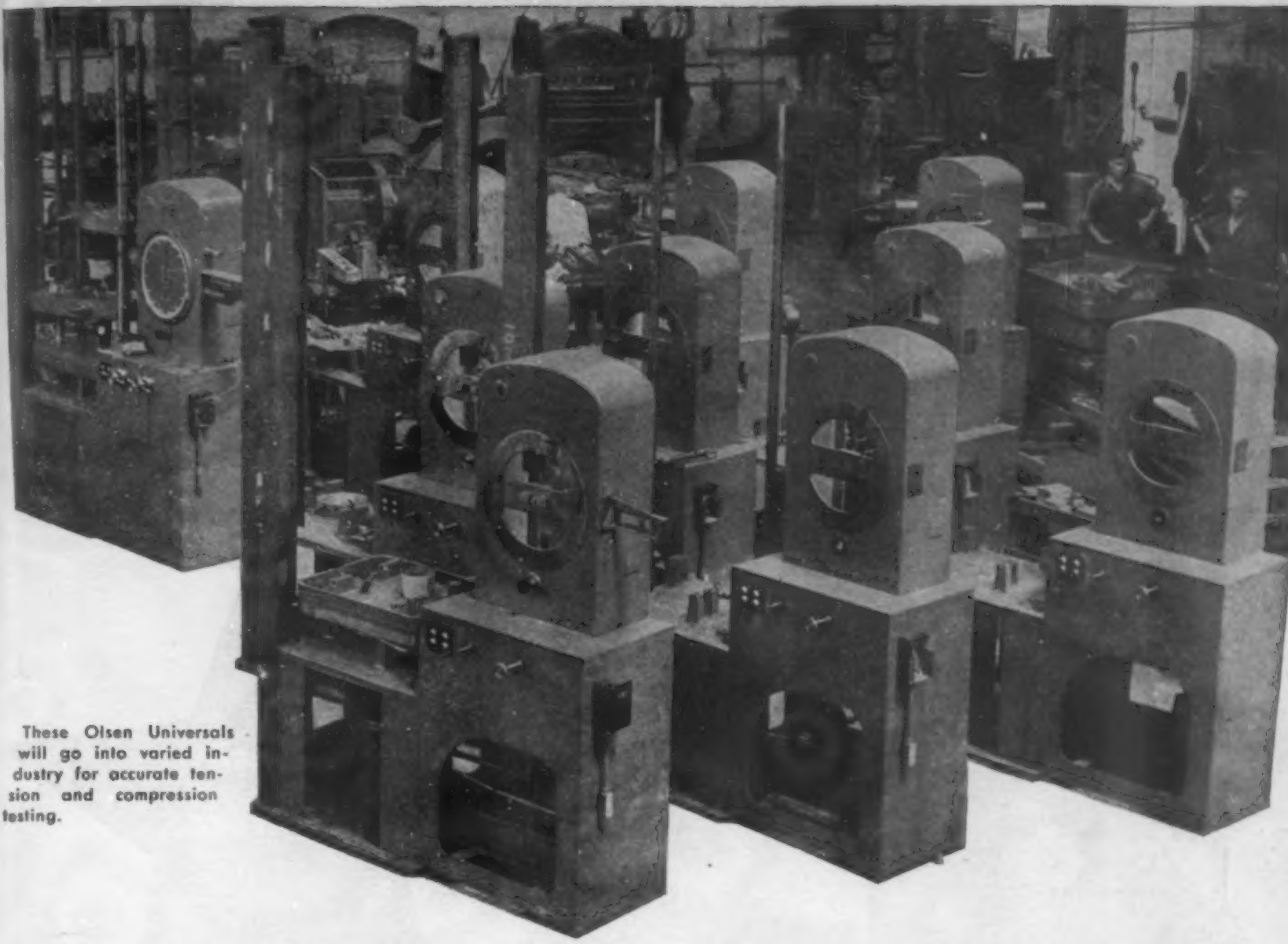
New York City Sales Agency: 27 West 20th Street · Chelsea 3-0267-8

Where and How can plastics help you win post-war profits

YOU'RE PLANNING NOW for civilian production when war restrictions end. And more than likely, you can use plastics for your product—or some part of it—with distinct advantages in production efficiency, economy and finer product quality. To aid you in redesign of such parts or complete products—and to acquaint you more fully with the characteristics of plastics—Amos has prepared a comprehensive booklet of fundamental and technical information on plastic materials and molding processes. Its comparative tables will give you a valuable key to many problems you face in ultra-modern product development. The booklet is free. You need only to write for it.

Custom Molders of Parts and Products by the Injection Process

AMOS MOLDED PLASTICS · EDINBURGH, INDIANA
Division of Amos-Thompson Corporation



These Olsen Universals will go into varied industry for accurate tension and compression testing.

DEFIANCE
Plastic Preforming Press

High speed production of plastic pills—with high uniformity in weight and density—is obtained with the Defiance No. 20 Plastic Preforming Machine!

Wide Range of Shapes and Sizes. Instead of the conventional round die with its many limitations, Defiance employs a rectangular die to increase capacity for multiple tablet making and to permit handling a wide variation of sizes and shapes.

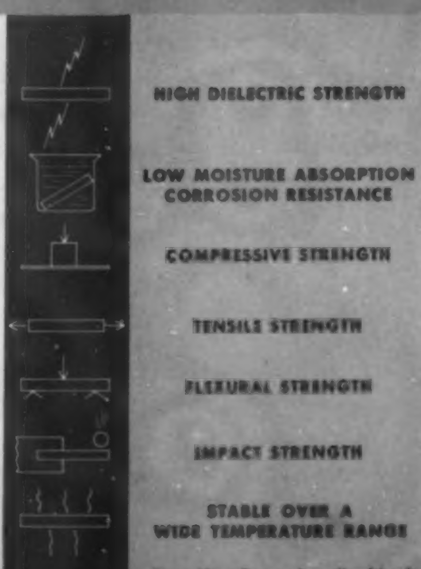
Engineered for Cleanliness! Easy to change colors with the Defiance Preformer—which means a minimum of "down time" for cleaning. Easy to keep clean, too—because Defiance reduces material leakage to a minimum.

Engineered for Uniformity! Exclusive features of Defiance design assure *accurate control of weight and density* in preforming plastic pills. This avoids waste, increases efficiency and saves money for the molder. Get in touch with Defiance for the *right* answer to your plastic preforming problems!

Defiance Machine Works, Inc., Defiance, Ohio.

hoto Courtesy Yerkes Observatory)

Clear Picture to the Strong Eye



THE Andromeda Nebula was just a blur in the sky until an inquiring mind and a telescope brought it into focus. Electricity was an awesome phenomenon until someone discovered how to use it. So it goes with all the unexposed realities in nature and science.

The future of plastics, in spite of already-known practical applications for them, is still a "blur in the sky." Engineers are getting a closer, sharper picture of what can and cannot be accomplished with them. The war has accelerated interest and action. But most of the work is ahead. The stimulus often, and logically, comes from the prospective user who knows his own requirements . . . from you, for example. If you'll write and tell us these requirements, we'll be glad to let you know, or find out, whether our type plastics will help.

SYNTHANE CORPORATION, OAKS, PENNSYLVANIA

Plan your present and future products with Synthane Technical Plastics

SHEETS • RODS • TUBES • FABRICATED PARTS — SYNTHANE — MOLDED-LAMINATED • MOLDED-MACERATED

SYNTHANE "Sandwich" Materials

One of the advantages of Synthane is the ease with which it can be bonded to other materials to produce a substance with the combined advantages of the partnership. Bonding takes place under heat and high pressure, during the polymerization of the Synthane; it is not a mere joining of two surfaces with an adhesive. The resulting combination, therefore, shows little or no tendency to delaminate.

Synthane combinations are familiarly known as Synthane "sandwich" materials, an appropriate name, for many different kinds of combinations are possible.

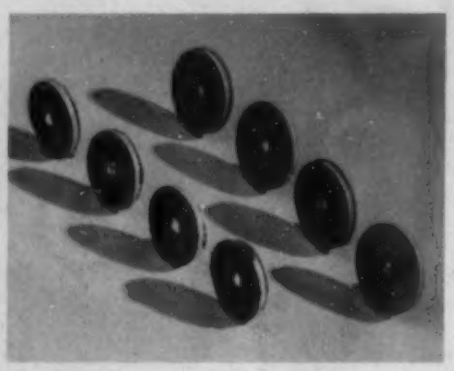
Probably the most widely used combination brings Synthane and rubber together.

Synthane-Rubber

Synthane-rubber combinations are advantageous where the strength of Synthane is desirable to back up rubber.

An interesting application concerns a washer used in electrolytic and oil type condensers. The washer is placed on the end of tin can electrolytic condensers with the Synthane face exposed to the chemicals to prevent deterioration. The can is crimped into the rubber to make a tight seal.

A similar washer is used on "bath-tub" condensers. Tough Synthane provides a firm seat for a nut which compresses the rubber to form a tight joint.



Combinations of rubber and Synthane have been furnished with rubber on one side, Synthane on the other; rubber on both sides with Synthane between; Synthane on both sides and rubber between; and alternate laminations of rubber and Synthane built up to any desired thickness.

There are many more possible uses for Synthane-rubber sandwich materials, which we cannot describe because of military censorship. There are also many important uses for a combination of Synthane and Neoprene.

Synthane-Synthane

Occasionally two grades of Synthane are combined. For instance, in certain radio tube sockets, layers of fabric

and paper base Synthane are combined. The paper base has usually better electrical properties while the fabric base furnishes added strength where the stress is greatest.

Bobbin heads in the textile industry are often made of paper and fabric bases combined. The fabric base endures rough handling, whereas the paper base on the inside of the head provides a smooth wearing surface.

Synthane-Asbestos

Synthane is wound about asbestos (or fibre) tubes and cured in the manufacture of tubing for large fuse cases. Synthane adds strength and rigidity to the fire resistance of the asbestos or fibre.

Synthane-Other Materials

Synthane can be united with a variety of materials to produce a variety of practical combinations. We have made or experimented with other combinations. If you have any combination in mind which we have not explored, we will be glad to investigate its possibilities for you.

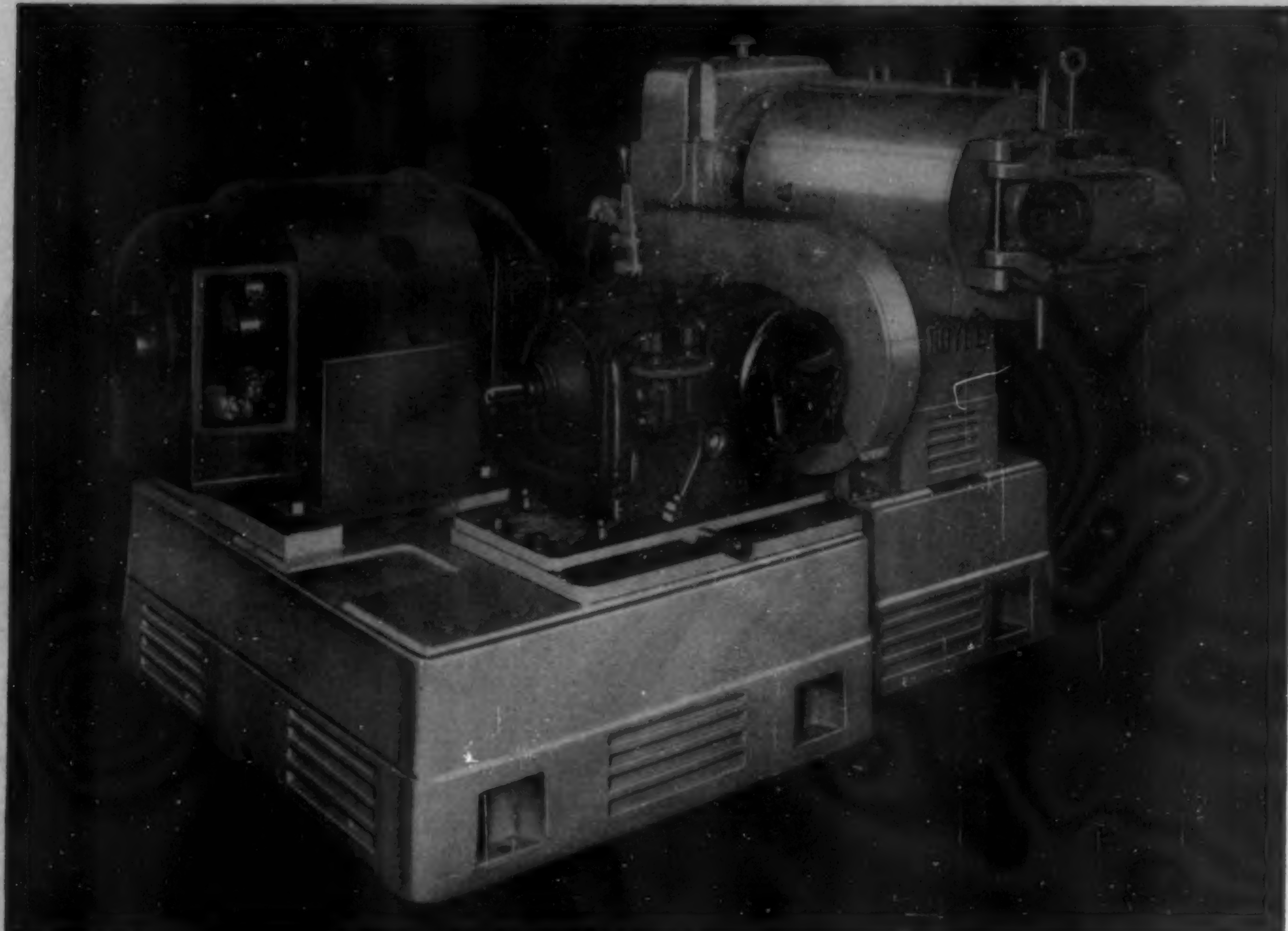
PLAN YOUR PRESENT AND FUTURE PRODUCTS WITH SYNTHANE TECHNICAL PLASTICS

SYNTHANE

SHEETS·RODS·TUBES·FABRICATED PARTS·MOLDED LAMINATED·MOLDED MACERATED

SYNTHANE CORPORATION, OAKS, PENNA.

REPRESENTATIVES IN ALL PRINCIPAL CITIES



"WE LIKE OUR HIGH SPEED EXTRUDER . . ."

A lot of water has flowed over the dam since the first Royle Extruder was introduced sixty-four years ago. In 1880—and during the following decade—an impenetrable veil of secrecy existed. No extruder had ever been seen in operation nor had any report on production achievements ever been received.

That veil of secrecy is gone. In its place has come a spirit of wholesome co-operation. This cooperative spirit makes it possible to design Royle Extrusion Machines to meet the specific requirements of the application involved. As always cooperation produces maximum results.

To-day, Royle production is devoted to the requirements of the Armed Forces. New applications of extrusion processes are being developed. These new processes hold promise of new and better products when victory has been won.

ARMY NAVY E

JOHN ROYLE & SONS

ROYLE PATERSON N. J.

PIONEER BUILDERS OF EXTRUSION MACHINES SINCE 1880

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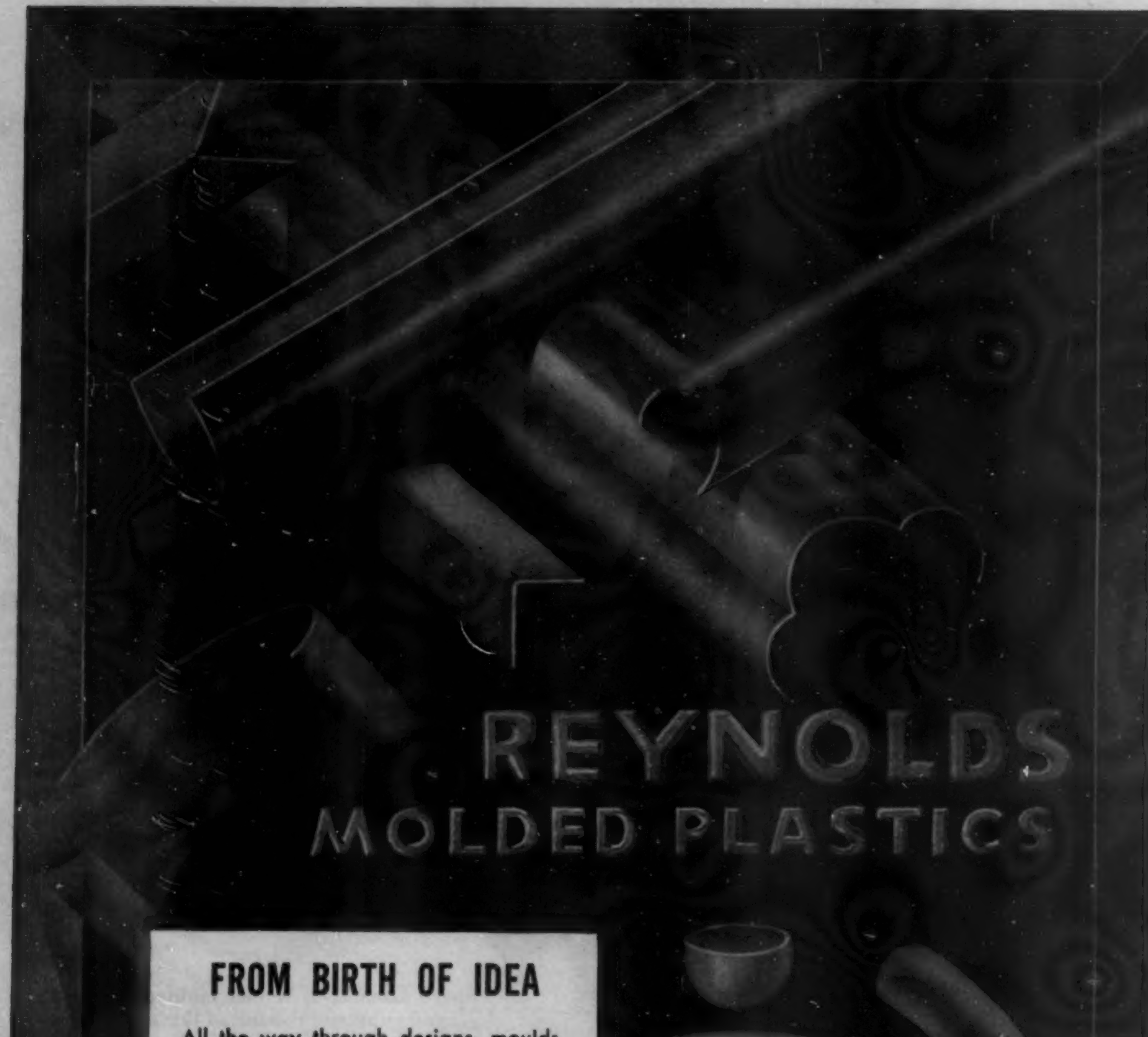
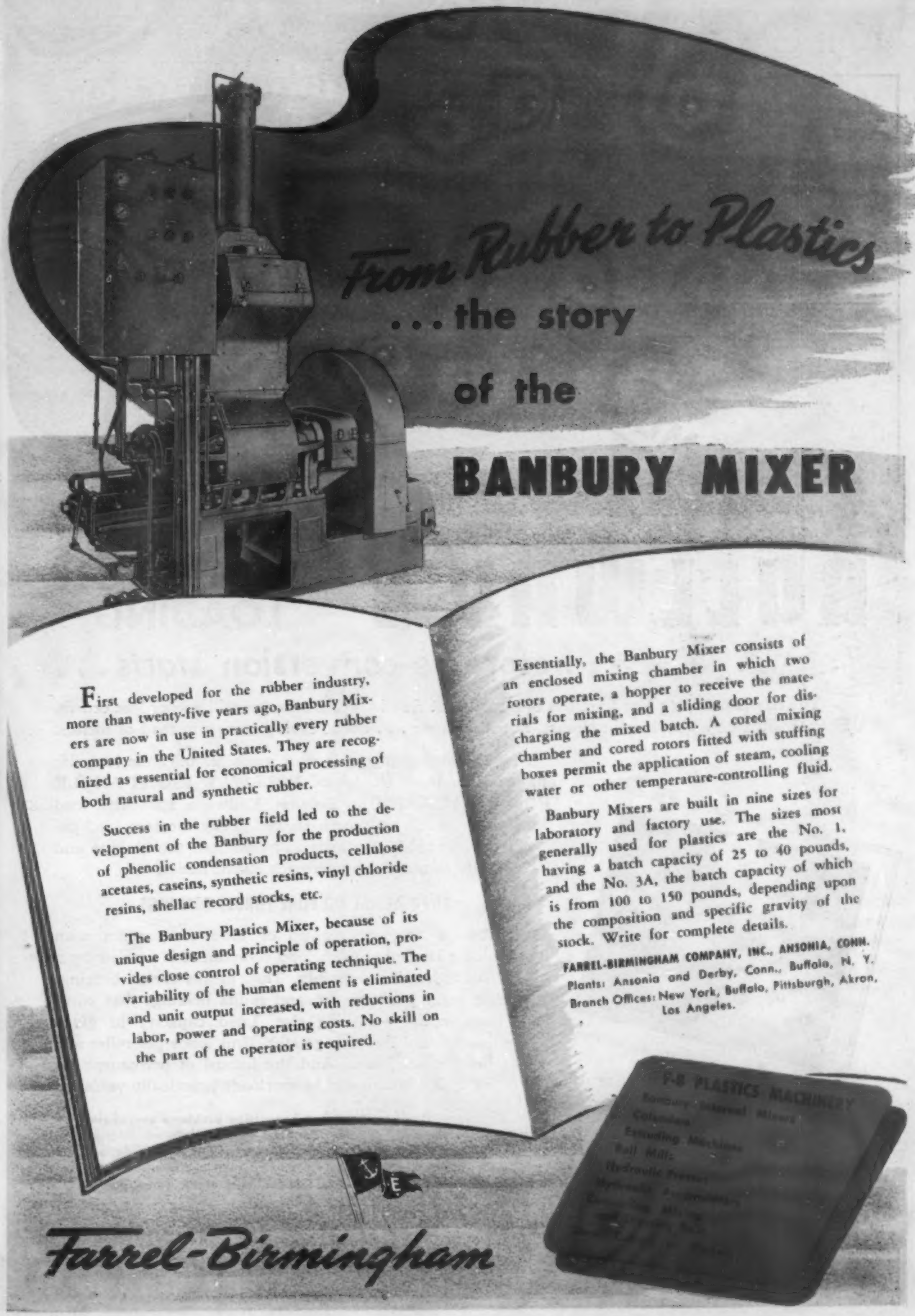
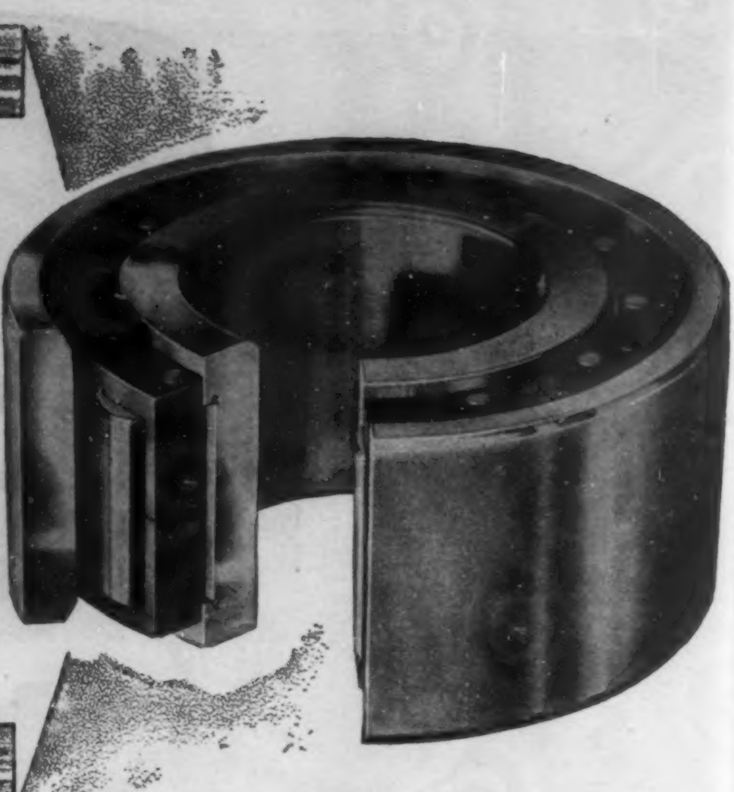
PATERSON 3, NEW JERSEY


REYNOLDS
MOLDED PLASTICS
FROM BIRTH OF IDEA
All the way through designs, moulds, engineering and complete finish the capable, experienced Reynolds organization will expertly engineer your plastic problems.
Plastics fabrication by compression, injection, extrusion, sheet forming.
INVEST IN WAR BONDS
REYNOLDS MOLDED PLASTICS
CAMBRIDGE, OHIO
Division REYNOLDS SPRING CO., Jackson, Michigan


From Rubber to Plastics
. . . the story
of the
BANBURY MIXER
First developed for the rubber industry, more than twenty-five years ago, Banbury Mixers are now in use in practically every rubber company in the United States. They are recognized as essential for economical processing of both natural and synthetic rubber.
Success in the rubber field led to the development of the Banbury for the production of phenolic condensation products, cellulose acetates, caseins, synthetic resins, vinyl chloride resins, shellac record stocks, etc.
The Banbury Plastics Mixer, because of its unique design and principle of operation, provides close control of operating technique. The variability of the human element is eliminated and unit output increased, with reductions in labor, power and operating costs. No skill on the part of the operator is required.
Essentially, the Banbury Mixer consists of an enclosed mixing chamber in which two rotors operate, a hopper to receive the materials for mixing, and a sliding door for discharging the mixed batch. A cored mixing chamber and cored rotors fitted with stuffing boxes permit the application of steam, cooling water or other temperature-controlling fluid.
Banbury Mixers are built in nine sizes for laboratory and factory use. The sizes most generally used for plastics are the No. 1, having a batch capacity of 25 to 40 pounds, and the No. 3A, the batch capacity of which is from 100 to 150 pounds, depending upon the composition and specific gravity of the stock. Write for complete details.
FARREL-BIRMINGHAM COMPANY, INC., ANSONIA, CONN.
Plants: Ansonia and Derby, Conn., Buffalo, N. Y.
Branch Offices: New York, Buffalo, Pittsburgh, Akron, Los Angeles.
F-B PLASTICS MACHINERY
Farrel-Birmingham

When Costs Count OVERLOADED BEARINGS MUST GO!



Switch to

ROLLWAY'S RIGHT-ANGLE LOADING

before re-conversion starts . . .

The day is coming when fractions of a mill—not fractions of a minute—will win or lose orders. Buyers will worry about maintenance, not manpower . . . about saving money instead of metals.

You'll be sitting pretty if your machines offer the long life and freedom from trouble of ROLLWAY RIGHT-ANGLE ROLLER BEARINGS. Because Rollways split the load into *pure* radial and *pure* thrust! They increase load capacity . . . banish overloads . . . eliminate the oblique and composite forces which overreach elastic limits.

- All radial loads carried at right angles to the roller axis.
- All thrust loads carried at right angles to the roller axis.

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Plastics are not likely to perform miracles, but if your business or employment involves products of wood, leather, metal, paper fabrics, rubber, ceramics, or coating materials, *you cannot afford to ignore plastics in your post-war plans.*

The impetus of war research; the discovery of new materials and new methods; the eminently satisfactory performance of plastics in replacing older materials during war is bound to bring manufacturing economies and improved consumer goods when peace returns.

The intelligent use of plastics can be determined best by knowing their limitations as well as their advantages; by studying their make-up and physical properties; by recognizing the peculiar characteristics attributed to each type of plastics material.

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Erie Resistor PLASTICS

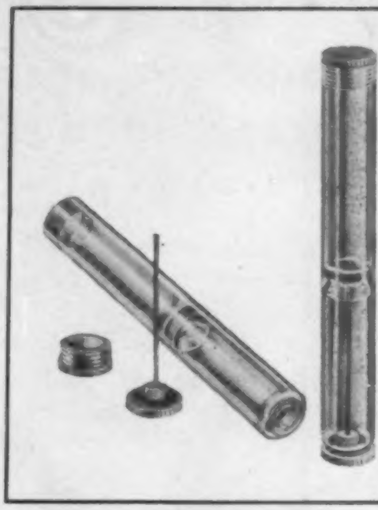
EVERY ounce of weight saved in critical metals, and every ounce of human energy conserved by lightening the equipment of the fighting man, is of extreme importance in today's war program. An excellent example of such double saving is the plastics oiler and thong case illustrated at the right.

Formerly made of metal, this case is now injection molded of Tenite, by the Plastics Division of Erie Resistor Corporation. The change to Plastics has resulted in five basic improvements—

1. Conservation of critical metals.
2. Reduction in weight.
3. Transparent:—contents may be inspected instantly.
4. Produced Faster.
5. Material is non-corrosive.

In molding this case of plastics, the skill of Erie Resistor engineers played an important part. Proper die design assured the production of a strong, durable assembly; oil-tight at the center bonded joint, as well as at the threaded ends, and by making the barrels of a softer flow material than the caps, the danger of binding or seizure of threads was eliminated.

This oiler and thong case is another example of how the Plastics Division of Erie Resistor combines the experienced talents of their Engineering and Molding Departments to produce molded plastic articles of mechanical strength and dimensional accuracy. Write for illustrated bulletin describing Erie Resistor Plastic Molding Facilities.



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Watertown molds the post war Sonotone Hearing Aid

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29 years of experience have equipped Watertown men with unique skill and highly specialized techniques which are being utilized in both war and essential post war production. Our facilities are extensive, embracing every phase from the formulation of resin to final buffing, polishing and assembly.

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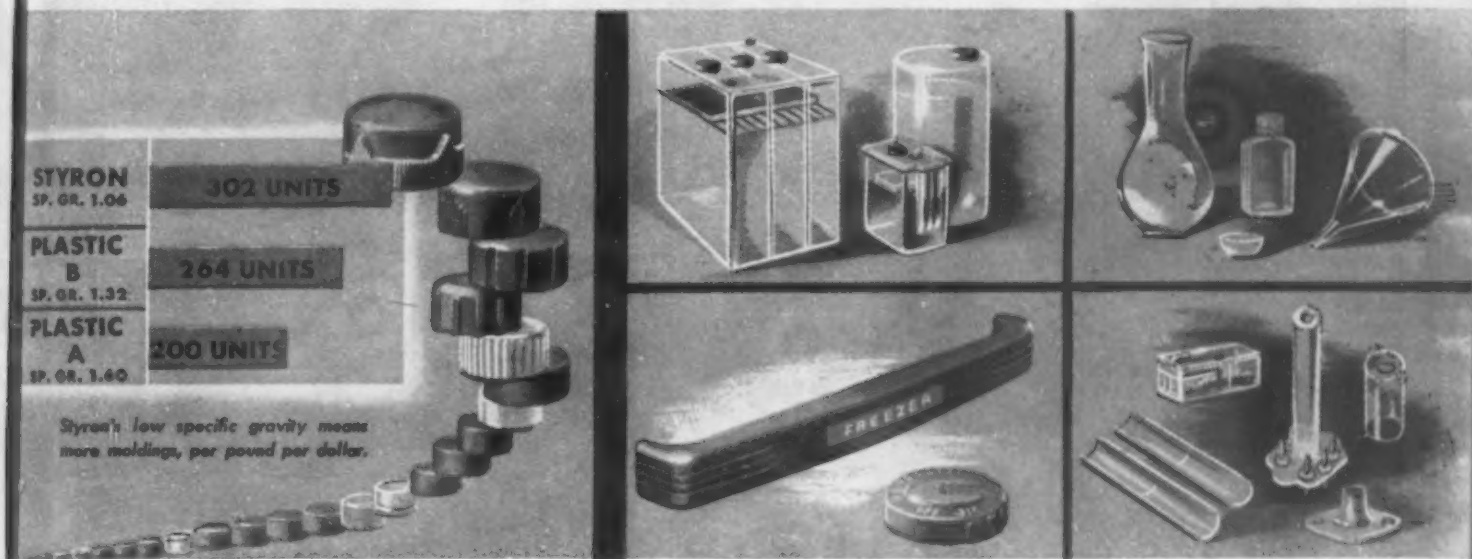
Huge war output of styrene holds this promise to Polystyrene users—a *top-ranking* plastic—at a *low price*—for *volume* production.



Today, all of us have but one objective—the winning of the war. Tomorrow we also have a great responsibility in the return to a peacetime economy—the responsibility to produce more and better products at a lower price. For these reasons plan now to use Styron (Dow Polystyrene). Large production facilities will make this versatile plastic available in a quantity, of a quality and at a price to meet the exacting needs of a product-hungry world.

The qualities of Styron have long since proved themselves in costume jewelry, colorful dishes, low-cost optical lenses, in precision products demanding low water absorption, in acid-resistant bottles and closures, in high frequency electrical equipment.

These are but a few jobs where Styron stands out. They suggest Styron's adaptability and wide range of usefulness. New forms will also be available for exciting and entirely different applications.

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DOW PLASTICS INCLUDE
- STYRON . . . for fabricators producing moldings, extrusions, rod, sheet.
- ETHOCEL . . . for fabricators producing moldings, extrusions, coatings; available also as Ethocel Sheeting.
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Write for new Dow Booklet "A Practical Approach to Plastics."

STYRON

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DOW PLASTICS


... Quality in The Making
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WHAT DO YOU THINK?

This is the second of a series of advertisements directed at the business executives whose decisions will largely shape the industrial future of America. It will appear this month in a group of leading news and business magazines.

The first advertisement in this series discussed in general terms the virtues and limitations of plastics under the headline, "There Are Some Jobs Plastics *Can't* Fill." This one takes the reader behind the scenes to show him one of the most significant of the plastics industry's recent developments and how it promises to enlarge substantially the number of jobs plastics *can* fill.

You will note that no definite promises are made and no extravagant pictures painted of a "brave new plastic world." Results already obtained in Monsanto's study of resin-fibre preforms in cooperation with a leading pulp molder, however, more than justify some hard-headed speculation like this on such possibilities as large plumbing fixtures, refrigerator parts and even furniture.

Experimental resin-fibre pieces are being produced in Monsanto's plastics research laboratories with tensile and flexural strength nearly double those obtained with present phenolic molding compounds . . . and impact strengths equal or superior to the best produced by high impact compounds . . . without any increase in water absorption . . . and without any sacrifice in appearance. Resin-fibre preforms are being molded to final finish and density, moreover, with pressures of 800 p. s. i. as compared with 3,000 p. s. i. for conventional fabric or cord filled compounds.

We feel that those facts and their implications should be brought to the attention now of the men who are planning now for tomorrow. At the same time we *discourage* over-optimism about plastics, we must also continue to *encourage* our prospects' interest in sound and logical new possibilities like these—or we may find the plastics industry in the position of the man who killed the goose that laid the golden egg.

Do you agree? Why not drop us a note and give us the benefit of your thought and experience on this, one of the most important postwar problems the plastics industry faces?

How to mold a plastics bathtub—*maybe*

Not so long ago talk like this of plastics bathtubs would have verged on sheer nonsense.

No laminated plastic could be formed into a shape as complicated as a bathtub. No molded plastic strong enough, could be molded into a shape that large.

But that was before the war—and before the development of resin-fibre, or pulp molding.

Now it is quite possible that some enterprising plumbing fixture manufacturer will someday scoop his postwar competition with a line of plastics bathtubs so light a plumber could deliver and install them singlehanded . . . so sturdy they would last the life of a house . . . and so attractive to the eye and warm to the touch that they would inaugurate a new era in bathtub merchandising.

To achieve the previously impossible of combining large size . . . high strength . . . intricate shape . . . and good looks . . . all in one plastic piece, your resin-fibre molder starts with paper pulp and a Resinox phenolic resin. He shapes them into a preform the approximate shape of the finished piece with a vacuum process, then molds them into final finish and density with conventional methods, or, perhaps, with the low-pressure techniques developed for resin impregnated paper, fabric and plywood aircraft parts.

By no means have all the problems of molding something like a bathtub yet been solved—but it can be said that molded plastic bathtubs, full-size radio cabinets, large refrigerator parts and even furniture are no longer idle Sunday supplement fantasies.

Experimental resin-fibre molding equipment has been set up in Monsanto's plastics research laboratories and one by one answers to the unsolved problems are being found—in cooperation with custom molders already using the new technique. If you would like to know more, write: MONSANTO CHEMICAL COMPANY, Plastics Division, Springfield 2, Massachusetts.

* * *

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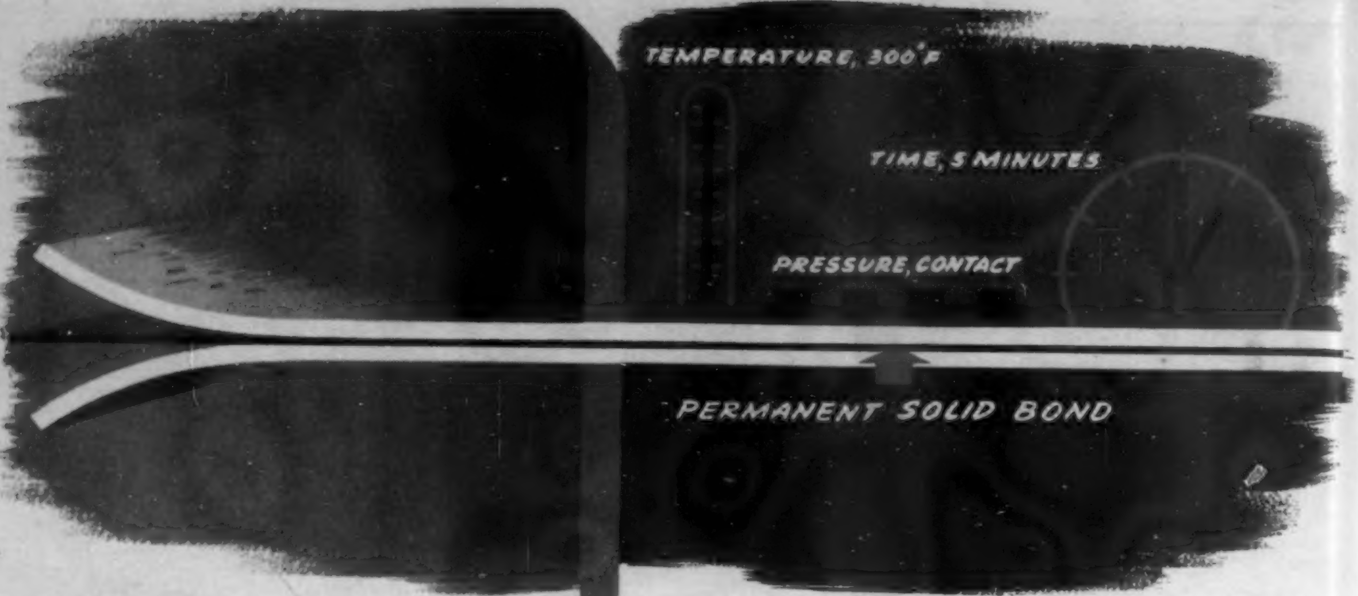

new, low-pressure PLYOPHEN helps to banish metal fastenings

The way has been cleared to dispense with time, metal, and money-wasting bolts and rivets in the joining of prefabricated laminated sheets. Now such sheets can be permanently and solidly bonded in one easy operation!

The secret of this remarkably simplified procedure lies in a bonding material prepared with a new, low-pressure RCI phenolic resin—No. 5013. Paper impregnated with this bonding material is placed, after drying, between the sections of laminate to be joined. Heat is applied to 300° F. *That's all*—and in five minutes, under simple contact pressure, the sections are solidly welded!

Highly versatile—No. 5013 is also widely used with certain high strength paper to produce—*under only 150 to 200 pounds pressure*—a laminate with a tensile strength of 35,000 to 40,000 pounds. And No. 5013 is only one member of the Plyophen line, which includes phenolic, thermo-setting laminating . . . impregnating . . . and bonding resins and varnishes for practically every purpose.

Write direct to the Sales Department in Detroit for details of properties and uses. And remember—RCI's quantity production assures prompt attention to orders.

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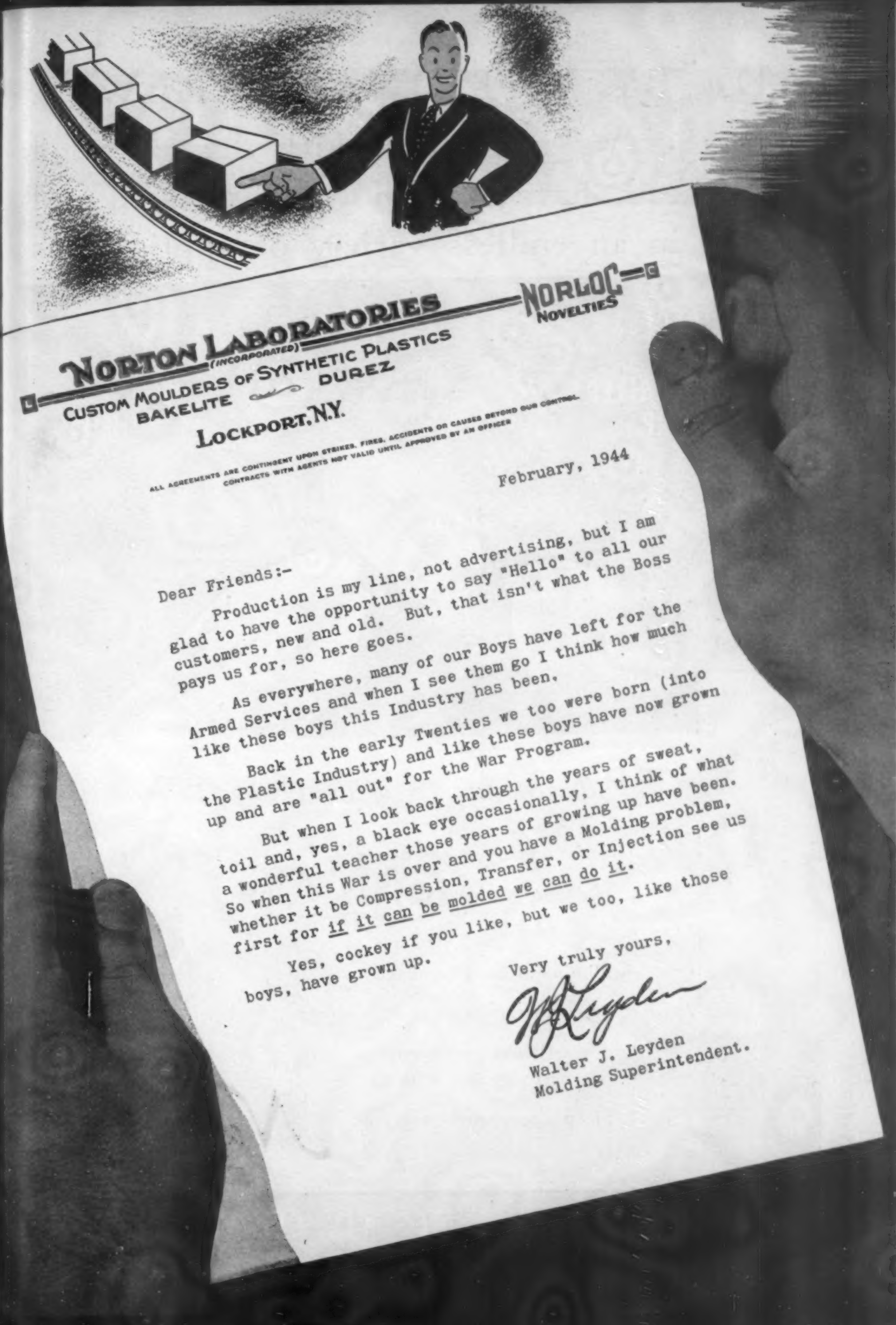

MODERN PLASTICS

FEBRUARY, 1944 VOLUME 21 NUMBER 6

Synthetics in shoes

by WILFRED GALLAY*

The stress of raw materials shortages has emphasized the question of the suitability of replacement materials for leather used in shoes. To clarify the situation, tests have been conducted in Canada on synthetic and leather uppers, insoles and outsoles

THE tremendous strides made in recent years in the development of a variety of synthetic materials have led naturally to an intensive search for applications of these substances in every branch of industry. The stress of raw materials shortages for military needs has accelerated the consideration and trial of novel substances for applications where the use of various well-known materials has been traditional. Such an alteration in technology obviously must meet with a large degree of inertia where one material has become so firmly entrenched for a specific purpose. But a broad view in trends in present day technology leads inescapably to the conclusion that such replacements will continue to occur to an increasingly greater extent.

The United States and Canada produce only a portion of their requirements of hides and tanning materials, and the question of the suitability of replacement materials for leather is therefore of considerable importance. Accordingly a considerable amount of attention has been devoted, in this laboratory and elswhere, to this problem—particularly during the past 18 months. In consideration of the problem several factors must be taken into account. The replacement material must be available in large quantities and, under normal conditions at least, must be able to compete with leather in price. This price factor may not be calculated on the basis of the number of units of service rendered since such a basis must involve long-term experience and confidence on the part of the ultimate consumer. Therefore the price, at least in the initial stages, must be reasonably competitive with leather on a straightforward volume basis. Assuming these factors, it remains to compare the replacement material with leather in all phases of quality requirements.

For the purpose of the present discussion, consideration of such relatively minor portions of the shoe as counters,

* Division of Chemistry, National Research Council, Canada.

PRESS ASSOCIATION PHOTO

1

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1—The sole and heel of the Canadian Army boot (left) is plastic. Welt construction is the same as in the standard Canadian Army boot (right) which has a leather sole and heel. Toe and heel plates used on the leather boot are not employed with plastic material. *2—Soling is tested for toughness and flexibility at −40° F.*

ining, shanks, welting, etc., may be omitted. Attention is focussed on three major constituents only—uppers, insoles and outsoles. These applications must be considered separately since the requirements of use show considerable difference. Discussion under these three application headings summarizes the requirements demanded of any proposed materials and, in the light of these requirements, compares leather and the synthetics known today.

Shoe uppers

For shoe uppers, leather shows certain admirable qualities. Properly manufactured it has excellent flexibility, and this necessary feature is well maintained at low temperatures. In general, the tensile and tear strength are ample for the purpose. The bursting strength, of importance in lasting operations, and the tearing strength with regard to stitch tear, eyelets, etc., also are adequate. Upper leather handles well in the operations involved in shoe manufacture. An important consideration is appearance, in that upper leather lends itself to the addition of such materials as can be buffed or dried to a high polish. Two important disadvantages of leather for shoe uppers are 1) inferior resistance to scuffing and 2) tendency to cracking in the vamp. Aside from the above, the great desideratum in a material for use in shoe uppers is ventilating quality. It is not commonly realized how efficient upper leather is in this respect. The average shoe upper actually transmits moisture vapor about $^2/_3$ as fast as the equivalent thickness of air.

Leather is a unique material in its combination of ventilating power with other fairly good qualities. It is safe to say that, at present, there is no substitute for leather in shoe uppers. Any consideration of synthetic materials for this application must include an adequate degree of ventilating power as a primary criterion of quality. Aside from appearance, the physical requirements noted above also must be adequately fulfilled. Here might be mentioned particularly the necessity of incorporating a high value for fatigue flexure and a good low-temperature flexibility. There would appear to be a possibility for the production at some future date of a fibrous synthetic material, porous in nature and quilted in some fashion to yield good strength properties. Another possibility which comes to mind is a multi-celled synthetic sheet with adequate open passages and the other requisite physical properties. It is apparent that such achievements are far from being fulfilled.

Shoe insoles

Many of the physical requirements of shoe uppers and shoe soling play a much lesser role in the case of insoles. Inferior portions of leather, i.e., inferior from the point of view of strength and abrasive resistance, are commonly used in shoe insole maufacture. The insole is protected by the soling construction and is attached also to the upper. Wear or scuffing resistance is not a requirement. A degree of flexibility is essential. Here again, ventilating power is obviously an important requirement in order to assist in the task of removing heat and moisture. Vegetable-tanned insoles are used almost exclusively for this purpose. Hardening and embrittlement of the insole during use is a serious problem in the shoe industry. A consideration of the possible use of a synthetic material for insoles must include the factor of ventilation. The possibility of dermatitic action of the constituents of a synthetic resin formulation also should be carefully noted.

Shoe soling

The factors entering into a consideration of various synthetic materials for use in shoe soling differ considerably from those noted above under shoe uppers and insoles. In view of the probability that the factor of ventilation can be disregarded, to at least a considerable extent, in shoe outsoling as will be discussed in detail below, the value of the synthetics can be assessed for immediate application.

There are listed below a number of characteristics which enter into an evaluation of a material under consideration

for use as shoe soling. In each case a summary is given of the relative merits of sole leather and synthetics which have been found suitable for the purpose. Chrome-tanned sole leather possesses certain disadvantages which have restricted its use to entirely negligible proportions. Therefore the sole discussed here is a high-grade vegetable-tanned leather.

Flexibility.—Sole leather can be processed to give a good range of flexibility for the purpose. The maximum angle of flexing required, even in very light shoe construction, is relatively small. As is well known, the synthetics can be prepared, either by suitable plasticization or in some instances by virtue of inherent properties of the resin, to yield a wide range of flexibility. This physical property is easily attained and eliminates only the rigid unplasticizable types of resins.

Resilience.—Resilience or temper in soling is of some importance in that the comfort in walking is affected to a considerable extent by the springiness of the sole. Leather is reasonably satisfactory in this regard owing to the small amount of over-all elasticity inherent in a system composed of closely interwoven fibers. Several of the synthetics are superior to leather in temper since a considerable portion of the stress applied in walking is returned during retraction, and this stress is better taken up by a temporary deformation of the material.

Tensile strength.—Vegetable-tanned sole leather has a tensile strength of the order of 2500–3000 p.s.i., and it is apparent that this figure is easily matched by most synthetics. Tensile strength becomes an important factor in shoe soling only as it plays a part in a consideration of wear resistance.

Tear strength.—Leather possesses good tear strength en masse because of the random interweaving of its fibrous constituents. However, in so far as the tear strength plays a part in wear resistance, leather shows the weakness of tearing over a considerable area followed by a separation of those fiber bundles which have been torn. The tear strength of an unvulcanized thermoplastic is relatively low, and it is considered that this type of compound should be reinforced by a suitable type of filler in order to enhance this quality.

Uniformity.—Physically, leather varies in thickness from hide to hide and over the area of a single hide. The fiber structure varies widely depending on a host of factors and, in consequence, the physical properties, e.g., strength, vary also. The angle of weave of the tanned protein fibers shows remarkable variation. Chemically, the quality depends largely on the details of the tanning procedure.

The synthetics have the obvious advantage of strict uniformity over any given area of sheet. Furthermore the thickness may be varied at will for various purposes. The use of a separate midsole and outsole is occasioned only by consideration of thicknesses of leather available. Therefore if a total of, say, 17 irons ($^{17}/_{48}$ in.) is required in the bottom construction, there appears no logical reason why this thickness cannot be better provided by a single unit of this thickness.

Resistance to high temperatures.—Damp vegetable-tanned sole leather is ruined within a very brief interval at a temperature of 80 to 85° C., and this deterioration will take place at temperatures as low as 50° C. over a period of a few days. An irreversible change takes place in the leather, which is very pronounced and accompanied by excessive shrinkage at still higher temperatures. In view of the very low moisture absorption of the synthetics, drying out is not a factor. Their resistance to such elevated temperatures as might be encountered in use as soling, in general, is more than adequate for the purpose.

Effect of low temperatures.—Leather maintains flexibility and resilience well at low temperatures. Any synthetic to be used as soling must show good toughness and freedom from brittleness at low temperatures for two reasons: 1) cracking of the soling at low temperatures must be avoided; 2) if elasticity is the chief criterion of good wear, as shown below, then this property should be maintained to as great a degree as possible at lower temperatures in order to preserve good wear resistance under those conditions.

Resistance to various chemical agencies.—Sole leather deteriorates with increase in pH, above the normal average figure of 3 to 3.5. The action of alkaline soils is well known in this regard. Vegetable-tanned leather has been shown also to deteriorate with decreasing pH not far removed from

3—***Soling mounted on the vertical wheel of this leather abrasion tester is worn against a horizontal disc of standard abrasive, under constant load.*** **4**—***This apparatus is used to determine permanent set of soling after test piece has been subjected to a load at an elevated temperature.*** **5**—***Tests on this machine determine resistance to stripping***

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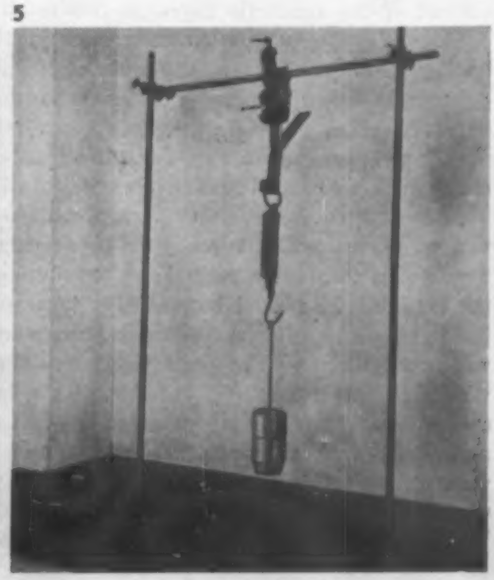


3. Leather therefore must be considered to show poor resistance to the action of relatively mild chemical agencies. The deterioration is very rapid in contact with more caustic chemicals. The synthetics are obviously superior on this count, and some of them show marked resistance to high concentrations of active deteriorating chemicals.

Water absorption.—Sole leather has an apparent density of about 1.0 and a true density of nearly 1.5.[1] It is obvious therefore that the percentage of voids is surprisingly great in a material of such firmness. The water absorption of sole leather (not waterproofed) is correspondingly great and in a standard immersion test may show an average of 40 percent absorption in a 3-hr. period and 20 percent absorption within 30 minutes. It is apparent that this constitutes a serious deficiency in a soling material both from the point of view of comfort and because of the fact that the wear resistance decreases under such wet conditions. The water absorption of the common synthetics, even of those normally considered for plastics purposes as being relatively low in water resistance, is very much less in all cases than that of leather.

Coefficient of friction.—Sole leather is known to be slippery on relatively smooth surfaces. The nonrigid synthetics vary considerably in this regard, but those suitable in other respects for soling are all considerably superior to leather in this respect. It is interesting to note here that too high a coefficient of friction is undesirable since excess energy is consumed as a result of the braking action in walking. On the whole, an intermediate value probably is to be preferred.

Dependence of properties on moisture content.—The physical properties of leather are dependent to a large degree on the moisture content. However the latter is in equilibrium with the surroundings which are to a large extent uncontrollable. It is apparent that the properties of suitable synthetics are essentially independent of the humidity in the ambient atmosphere of contact with water.

Behavior in manufacturing operations.—Sole leather, as might be expected, handles well in manufacturing operations on machines designed for the use of leather. It is important from the practical point of view that synthetics proposed for use as soling shall be readily and conveniently handled by existing machinery and processes. This should form one of the items of preliminary investigation of any new material. The formulations prepared in this laboratory have shown excellent properties in this regard with the one exception that buffing of edges of the sole to a smooth finish is a very difficult matter. Application of a coating of a cement of the synthetic improves this finish considerably.

Ventilating power.—As noted earlier in this discussion leather is unique in its combination of striking ventilating power with other properties. There is no doubt as to the necessity of a material with good ventilating properties for use as uppers and insoles. In the matter of soling, however, two factors must be taken into consideration.

One of these factors is concerned with the addition of various materials to the soling or between layers of soling which tend to nullify the inherent ventilating properties of the leather. The usual bottom filler between midsole and insole, consisting of a mass of tar and ground cork, obviously will not ventilate. The same holds true for any efficient water-proofing agent for outsoles. This laboratory has carried out dozens of tests on water-proofed sole leather for military boots. The permeability decreases as the degree of water-proofness increases. In all cases which were examined where the leather was really water-proofed, the leather also had almost zero permeability to water vapor and air.

The second of the factors involved in this question of ventilation is the doubt which may logically be cast on the importance of ventilation in the soles fo shoes. In the very few statistical studies of comfort which have been made in a comparison, say, between leather and rubber as shoe soling, one finds only a surprisingly small advantage in comfort in favor of leather. This is an involved problem, and deserves a great deal more attention.

Of course the synthetics are non-porous and must be considered as having zero ventilating power. It would appear from present information altogether unlikely that this is a factor of any appreciable importance in the case of soling. Nevertheless it would be very much worth while to analyze reports of comfort over a large number of users.

Wearing quality.—Wear resistance is the obvious main criterion of quality in a soling material once the fundamentally requisite physical qualities are assured. It is apparent that any material which may be considered practically for shoe soling purposes, will be very much softer than the abrasive materials with which it comes in contact. The soling must have a low rigidity and be able to back away from, or ride over, the abrasive particle. The whole of the stress-strain cycle is of importance, and as much as possible of the energy input should be returned during retraction. The hysteresis loss, in other words, should be low. Summarized, this means that the soling material in order to show a high wear resistance, must possess a high degree of elasticity. The term elasticity is not used here in the sense of conformance to Hooke's Law as in the case of rigid materials, but rather in the wider sense of what is sometimes termed "high-stretch elasticity," or a relatively low energy loss combined with a fair degree of stretch. It is quite probable that ultimate tensile strength and tear resistance also play a part.

Replacement materials

The rigid types of plastics may be eliminated at once not only from the point of view of lack of flexibility but also because such materials show in general a surprisingly inferior wear resistance. Flexible thermoplastics which are essentially plastic rather than elastic, show poor wear in conformity with the argument given in the preceding section. We have carried out wear resistance determinations on various formulations of cellulose esters and ethers, and the results were relatively poor. If some small degree of elasticity was incorporated, as for example in an ethyl cellulose plasticized with a vegetable oil, a corresponding increase in wear resistance was noted.

The synthetic materials for shoe soling therefore should be of the elastomer type. These might be of the synthetic rubber class or the elastomeric thermoplastic class of compounds. In view of the most recent developments of the past few months, the previous distinction between these classes, viz., vulcanizability, is rapidly disappearing, and it is becoming increasingly difficult to set up this sort of classification. Probably it would be preferable to refer simply to elastomers in the wider sense of the word.

Unfortunately there is as yet very little known theoretically about the action of plasticizers on these resins. Hence plasticization at present is essentially on an empirical basis. This is particularly important since many synthetic resins are virtually useless without plasticizers, and frequently a resin compound contains as much plasticizer as resin. The relation between the type of (*Please turn to page 180*)

[1] W. Gallay and J. S. Tapp, Jour. Amer. Leather Chemists Assoc. 37, 140–50 (1942).

The ice cube tray, jar top, sheeting, collapsible tube, wire insulation, tubing, bottle stopper and injection-molded grommets show some possible future uses for polyethylene. Present production is subject to war allocations

Polyethylene—a new thermoplastic

by DR. J. W. SHACKLETON*

THE year 1943 saw the beginning, in this country, of the production, for war purposes, of commercial quantities of a new plastic which possesses a remarkable combination of useful properties. This is the hydrocarbon resin, polyethylene, made by the polymerization of ethylene:

$$n\left\{\begin{array}{cc} H & H \\ | & | \\ C & = C \\ | & | \\ H & H \end{array}\right\} \rightarrow \cdots\cdots - \begin{array}{cccccc} H & H & H & H & H & H \\ | & | & | & | & | & | \\ C- & C- & C- & C- & C- & C- \\ | & | & | & | & | & | \\ H & H & H & H & H & H \end{array} \cdots\cdots$$

ethylene — polyethylene

To this solid, tough polymer, originated by Imperial Chemical Industries, Ltd., has been given the generic name, polythene.

Polythene is a thermoplastic resin which can be readily molded by injection or by compression, or extruded to form sheets, films, fibers, tubes and the like. Because of its modulus of rigidity, polythene occupies a peculiar place among the plastics. In thin sections it may be classified as nonrigid, yet it lacks the limp, rubbery quality that characterizes most nonrigid plastics. On the other hand, polythene in thick specimens has enough stiffness to class it among the more rigid plastics. Incongruous results are often obtained, however, when rigidity, impact strength and related properties of the plastic are measured by standard methods.

Polythene in uncompounded state has a waxy white, translucent appearance. By quenching, it may be made transparent in thin sections. A compilation of some of the physical and chemical properties of polythene is given in Table I. The outstanding properties upon which it is expected that many important uses will be based are its flexibility and toughness over a wide range of temperatures, its unusually good resistance to water and to penetration by moisture, its chemical inertness, and its excellent electrical properties.

Injection-molded standard Izod specimens of polythene are not broken in a 2-ft./lb. impact tester. At $-45°$ C. strips of polythene 0.075 in. thick are not broken by a sudden sharp bend. The water-absorption in the standard ASTM test is 0.075 percent. The transmission of water vapor is low, e.g., by sheeting of 0.004-in. thickness 0.4 gram, and by sheeting of 0.010-in. thickness 0.07 gram per sq. m. per 24 hr. at 25° C. Its specific gravity, 0.92–0.93 at 20° C., is as low as that of any other plastic.

On the basis of experience with polyethylene's current applications and of consideration of its properties, polythene may be expected ultimately to find extensive use in various forms for a wide variety of purposes. The toughness, flexibility, low water-absorption and moisture impermeability of polythene will make it suitable, *(Please turn to page 178)*

* Technical Service representative, Plastics Dept., E. I. du Pont de Nemours & Co., Inc.

"LAY THAT PISTOL DOWN"

AMONG the noteworthy contributions of plastics engineers to the war effort must be listed the development of many useful weapons. Transfer-molded gun butts, bayonet grips molded of both thermosetting and thermoplastic materials, plastic gun grips and plastic training bayonets—these are but a few of the outstanding achievements accomplished since Pearl Harbor. One of the most recent and probably one of the most novel additions to this field is a cellulose acetate and metal .45 caliber training revolver which will do everything but shoot.

In spite of the rapid advances in mechanized warfare which have been made since the first World War, practice in hand-to-hand combat still constitutes an extremely important part of military training. Practically every man in the armed services is schooled in the use of a standard .45 caliber revolver regardless of whether he is destined to carry one in actual combat. It takes thousands of pistols to meet this demand and when the supply became tight, Naval officials were forced to seek a substitute weapon. In the course of this search various types of dummy pistols were examined. However, none of them met all the necessary requirements.

Finally, the problem was presented to a midwestern molding company. Within 5 weeks' time, this plant had made an exact replica of the original weapon. However, before the pistol was approved for production, Naval specifications demanded that it successfully pass an impact resistance test which involved dropping the parts from a height of 6 ft. at temperatures of -30 and $160°$ F. This was undergone with no ill effects, and an initial order was immediately placed. Additional samples now are being tested at various Army camps to determine the training possibilities of the weapon for this branch of the service. The primary object of the Navy was to secure a dummy pistol for use in the hand-to-hand combat instruction given to preflight trainees.

4

1—Training in the disarming of an opponent starts with the instructor's pistol drawn and the trainee's hands raised above his head. 2—To prevent a gun from being discharged, pressure is exerted against the muzzle, causing the slide to move back. 3—An opponent can be brought to the deck if his pistol is seized and twisted outward toward the trigger finger and the back of the opponent's hand. 4—The completed dummy revolver (A) consists of the metal insert (B), the trigger (C), the trigger guard (D), the spring (E) and the spring adjusting screw (not shown)

5 PHOTOS, COURTESY CRUVER MFG. CO.

6

5—The CT metal insert (B in Fig. 4) is in its correct position in the mold, ready for the molding of the .45 dummy revolver. 6—Upon completion of the molding cycle, the mold is opened with hand-operated cams. The large gate and runner can be seen at the right. 7—A cross section of the .45 automatic practice revolve

Every man who rides in a Naval combat plane receives extensive training in how to disarm an enemy so that he may have a fighting chance when he knows that death or imprisonment will result if he submits without a struggle. Now that the new dummy revolver is available for this course, instead of pretending to knock his captor's pistol to one side, each student can make his feints and grab for his adversary's gun exactly as if it were the actual firing weapon. He then can proceed to carry out such instructions as that which follows (depicted in Fig. 3): "Continuing twist, locking opponent's trigger finger in trigger guard. Added pressure will bring him to the deck."*

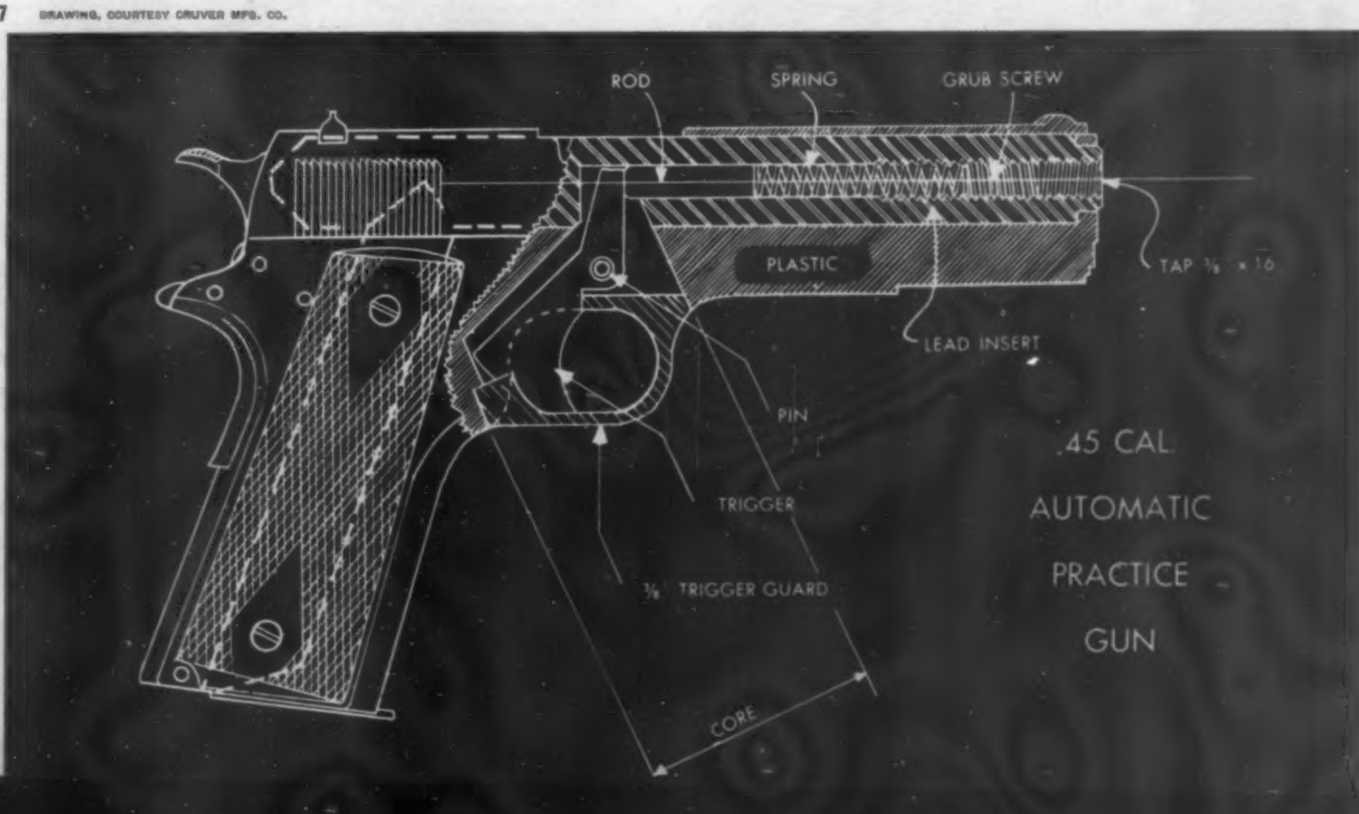
The experiments with the plastic pistol, which now are being conducted by the Army, are built around the idea of using the gun as an aid in firing instruction. Every man who has ever fired a high-powered rifle or a pistol knows that the trigger must be squeezed rather than pulled. Consequently, hours are spent in training men in this technique so that there may be no deviation of aim due to trigger jerking.

To meet all of the above-mentioned requirements, the molding company first designed a combination metal and cellulose acetate pistol to the correct proportions for balance and weight. In addition, it was essential to develop a type of trigger which would exert the same pressure as that obtained in the case of the standard .45. The trigger also must be able to stand up successfully under a great deal of hard use. Because of the variation inherent in all springs, a method had to be devised for adjusting the trigger spring so that the triggers in all the revolvers could be made uniform.

The first step in solving these problems was the design of the metal insert (Fig. 4, B) which (*Please turn to page 184*)

* Quoted from Navy manual, "Hand-to-Hand Combat."

7 DRAWING, COURTESY CRUVER MFG. CO.



New developments in furane resins

by JOHN DELMONTE*

One hundred percent furane resins which can be molded, laminated, cast, sprayed as air drying coatings and used as adhesives and impregnating agents, have been developed experimentally. The 2 figures (left) illustrate results obtained from the impregnation of plaster of paris pieces

FURFURAL plastics have for many years been identified with phenolic resins, wherein the formaldehyde ordinarily employed is replaced with furfuraldehyde to form useful synthetic resins. It has also been known for some time that furfural itself will resinify in contact with acids though the end products were of questionable usefulness. The technique of preparing useful resinous products from furfural alone has been under investigation for several years, and some measure of success has been achieved. One hundred percent furane resins which can be molded, laminated, cast, sprayed as air drying coatings, and used as adhesives and impregnating agents, have been developed experimentally.

Development

These furfural resins can be identified broadly as thermosetting materials though by appropriate modifications thermoplastic derivatives are readily achieved. While the commercial applications of furfural resins have not been exploited at this time, one can expect that important developments should take place in the not too distant future. Some of these developments may be due to an easing up of furfural restriction because of greater availability of the raw material; others may result from competition between furfural and formaldehyde, the termination of basic patents on the phenol-furfural reaction, and further advance in the production of furane derivatives alone.

Furfural ($C_4H_3O{\cdot}CHO$) is a light brown colored liquid which becomes darker on aging. It is obtained from various vegetable by-products such as bagasse, flax straw, oat hulls, rice hulls, cottonseed hulls, wood wastes and others. Commercially, at present, oat hulls are the most prolific source. Current prices for furfural based on present production are in the neighborhood of 10 cents a pound. Best known furane derivatives include furfural alcohol, hydrofuramide and tetrahydrofurfural alcohol. The last mentioned derivative has attracted interest lately by reason of the various high boiling point esters synthesized from it. Tetrahydrofurfural alcohol has shown greater stability than have other forms of furane derivatives.

Among the unusual qualities of some of the 100 percent furane resins is the fact that they remain liquid until they are converted to the Stage *C* insoluble, infusible form. In general the polymerization of furane resins may be marked by three stages: Stage *A*—chemical activity quite pronounced; Stage *B*—less chemically reactive state than *A* and distinguished by resin polymers of varying viscosities; and Stage *C*—the infusible, insoluble state comparable to the cured phenol-formaldehyde resin. In general, Stage *A* resins possess the best penetrating qualities and Stage *B* resins are most useful as coating and adhesive intermediates. While their properties are basically different from other synthetic resins, the 100 percent furane resins bear a close resemblance to phenol- or cresol-formaldhyde types.

Castings

Furane resins show excellent properties as casting compositions with fillers or as extenders for phenol-formaldehyde casting resins. This characteristic may be expected to be quite interesting inasmuch as these liquid thermosetting resins contain little or no volatile matter. The resin may be prepared in a broad selection of viscosities, and the inclusion

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of fillers is a relatively simple problem as compared to some of the difficulties experienced in handling more viscous types of resins. The amount of filler which can be added depends naturally on the specific gravity of the filler, its mesh size and whether the resin is absorbed into the filler or adsorbed on the surface. For fillers with a specific gravity about 2.5 and a finely divided mesh size, sufficient material can be added to leave the final product with 70 percent filler and 30 percent resin by weight, and still be pourable at room temperature.

Up to 50 percent woodflour may be included with the liquid furane resin without the aid of further solvents. The filler reduces shrinkage tendencies and is to be preferred for most castings of pure furane resins. Curing temperatures are in the neighborhood of 170 to 180° F., though for some combinations a preliminary low temperature of 125° F. for several hours, followed by the high temperature up to 24 hr. may give best properties. Compressive strengths of 15,000 p.s.i. have been obtained upon several of the 100 percent furane resins.

Up to the present most attention has been given to the use of furane resin polymers as extenders for phenol-formaldehyde resin polymers. They are compatible in all proportions. In Fig. 2 stress-strain characteristics of a typical phenol-formaldehyde cast resin are compared with the same resin extended with 50 percent furane resin polymer. Noteworthy is the greater deformation realized for the material extended with furane resin, which is indicative of greater toughness—a quality so desired in various tooling applications. Another advantage of the furane resin extended type is that it is more fluid at the time of casting which means fewer air bubbles and which simplifies the problem of including more fillers. A typical cut and polished cross section of furane resin casting is shown in Fig. 5.

Through proper catalyst selection, cold-setting cast resins have also been prepared from 100 percent furane resins. This enables slush castings to be prepared around the inside of metal or rubber molds. The time of setting may be regulated by catalyst control. Rubber is slightly attacked by some types of furane resin, and difficulty may be experienced in stripping it from the rubber unless the piece is removed before it has fully cured.

Moldings

Various moldings have been prepared from furane resins although not much stress has been placed upon this activity because recent demands for new plastic materials have appeared in other types of application. However, Fig. 6 shows a typical molded part prepared from 100 percent furane resins about two years ago. Moldings have been prepared at temperatures of 290 to 350° F., though a range of 290 to 320° F. appears best. Furane resins molded parts appear softer than phenol-formaldehyde parts at the molding temperature though they can be safely ejected while hot. Pressure and curing times are comparable to those of the phenolics. Properties are of course dependent on the fillers.

Furane resin impregnated pulp preforms are readily molded to form tough, stable materials. Unlike the usual phenolic resin process wherein the aqueous resin is introduced into the slurry with the pulp, furane resins can be used to penetrate the dry pulp preforms very rapidly and then be molded with good results. This permits a very efficient use of the resin.

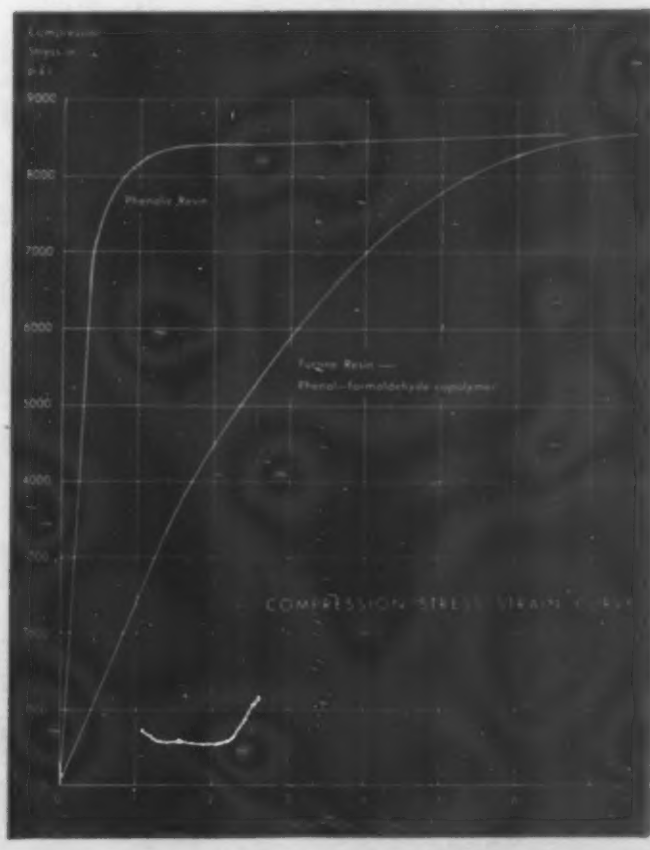
Adhesives

One of the most interesting applications of furane resins has been in the field of resin adhesives. They can be supplied in both hot-setting and cold-setting (room temperature) types. Possessing very low water absorption and good resistance to boiling water, furane resins should display satisfactory aging characteristics. In some of the shear tests on bonded compreg and laminated phenolic strips, failure took place in the strips of plastic rather than the glue line. These laminated canvas and compreg pieces were not given any pretreatment on their surfaces and were bonded at room temperature without clamping pressure.

Curing conditions follow much the same practice already established for urea-formaldehyde adhesives. It appears desirable to withhold catalyst until the glue is to be made ready for application. Cold-setting furane resin adhesives have been prepared to bond wood, cloth, metal, laminated phenolics, rubber, masonry, ceramics and most synthetic resins and cellulose derivatives. The unusually good bonding properties of this resin can be attributed to its penetrating qualities and, in the case of thermoplastics, to the solvent action it has on the material. The cold-set types are handled much like ureas with one possible exception They are more sensitive to catalyst and at present will have a limited shelf life after mixing in catalyst. However, if the adhesive is refrigerated or cooled by a water-jacketed vessel before mixing, it will be satisfactory for a few hours and then will set firm as it warms to room temperature. All utensils and clothing should be wiped clean with acetone directly after use. Shear values after 96 hr. should approach 2000 to 3000 p.s.i. on laminated phenolics as tested by the 3-ply block technique with the load applied on the center block. In most wood specimens there is 100 percent wood failure.

To indicate possibilities yet undeveloped, the following have been accomplished experimentally: a cold-set plywood adhesive which passes the boiling water test required in Army-

2—Stress-strain characteristics of a typical phenol-formaldehyde cast resin in comparison with the same resin extended with 50 percent furane resin polymer

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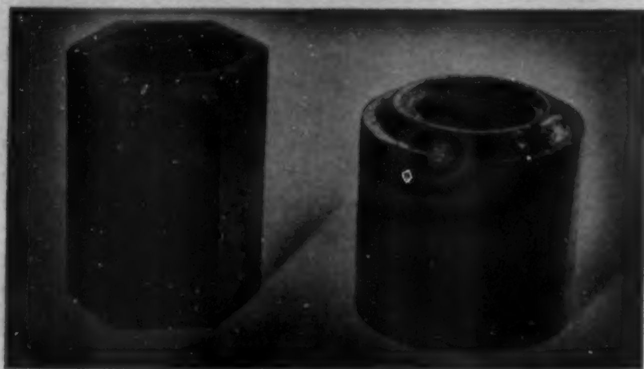
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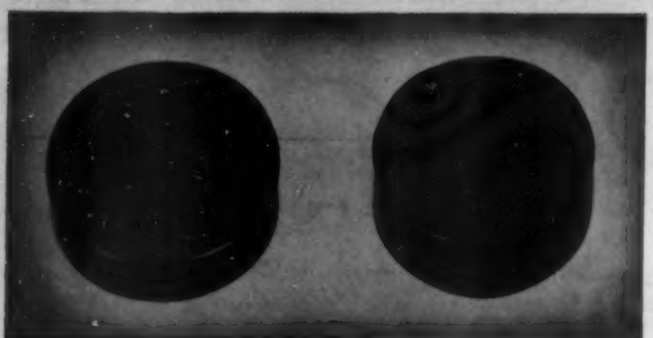
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3—Both high- and low-pressure laminates have been prepared with this resin. 4—These 2 pieces are representative of easily impregnated pulp preforms treated with furane resin. 5—A typical cut and polished cross section of a furane resin casting. 6—A typical mold prepared from 100 percent furane resin 2 years ago

Navy Aeronautical Specifications and in the strip shear test has 100 percent wood failure; bonding of various plywood panels surfaced with cellulose derivatives and sheets of thermoplastic synthetic resins, with a perfect bond in the furane resin due to its solvent action upon these materials.

Laminates

Both high-pressure and low-pressure laminates have been prepared with furane resins with interesting results. Some typical laminates appear in Fig. 3. Among the more interesting aspects of these laminates is their ability to penetrate thick papers or even thicker pulp, which suggests that there is a possibility of developing thick sections without numerous layers.

The hot bonding of plywood with furane resins is usually distinguished by penetration of the resin through the pores. This is easily noticed because of the dark color of the furane resins and is indicative of the firm attachment to the wood structure. On the other hand, some compensation can be made to avoid starving of the glue line. Wood fully impregnated with furane resins may be readily prepared without elaborate impregnating means and fully converted by heat or heat and pressure. Advantages are apparent by reason of the excellent water resistance of furane resins. On the other hand furane resins, like other low-molecular weight resins, possess a notable weakness in impregnating woods. The lower the the molecular weight of the impregnating resin, the better the impregnation generally and the more brittle the end product.

The furane resins also show promise in the production of low-pressure cloth and glass-fabric laminates, particularly the latter, where the high strength properties of the glass cloth are reflected in the finished laminate.

Coatings

The excellent compatibility of furane resins marks these materials as good extenders or coating agents for innumerable industrial products which can tolerate a dark finish. These coatings have been applied both by dipping and spraying. Among the unusual coatings developed has been a 100 percent furane thermosetting resin which will air dry to the touch at room temperature in 10 to 15 min. and harden quite firmly in several hours. Metal and wood panels so protected have shown good weatherability. The resin shows promise as a wood sealer against transmission of moisture to or from wood structures. This material has also been applied as a cement and ceramic sealer.

Impregnants

As an impregnating agent furane resins do not have many equals. Cloth, cotton, felt, plaster of paris, etc., are readily impregnated with heat-curable furane resins. Figure 4 illustrates easily impregnated pulp preforms treated with furane resin. These are penetrated at atmospheric pressure within a matter of seconds. The cellulosic material is rendered quite hard and waterproof by such treatment; the impact strength of the impregnated product will depend on the technique of applying and curing the furane resins.

Figure 1 shows more difficult impregnation—plaster of paris pieces. The plaster of paris, preferably dry, readily soaks up the material. The final form may contain as much as 30 percent furane resin. Best physical properties are developed by curing overnight at temperatures of 170 to 180° F. The plaster of paris is quite hard after curing and readily buffed to a high polish. Overall dimensions are substantially unchanged after resin impregnation and curing. The mold shrinkage problem encountered with some cast synthetic resins is eliminated.

Properties

A complete series of tests have not been performed upon all types of the furane resins, but some (*Please turn to page 182*)

Postwar uses for luminescent pigments

by V. A. BELCHER*

PROBABLY some of the most interesting plastic applications in the postwar period will be those involving luminescence. This seems to be indicated by a number of wartime uses effectively combining luminescent pigments with many plastics and by the reduction of costs to a much lower peacetime basis than that prevailing before the war —a reduction made possible by greatly increased production of luminescent pigments. Some of the possible future uses are listed at the conclusion of this article.

For some uses the luminescent pigment is incorporated with the resin before the molding or casting operation. Necessarily, such plastic materials must be of the transparent or translucent types to permit sufficient luminescence. In many other applications the plastic item is molded and finished, after which the luminescent pigment is applied by one of the printing processes—letter press, silk-screen, lithography, dusting (bronzing) method or decalcomania.

Luminescent pigments now are being manufactured and used on a tonnage scale. Practical applications of some of these pigments have been made in combination with nitrocellulose, cellulose acetate, polystyrene, vinyl resins and methacrylate. All, or almost all, of the present applications are for war purposes, some of which are illustrated by the accompanying photographs.

The price of luminescent pigments has been reduced from the cost that prevailed a few years ago of about \$8.00 to as high as \$30.00 per lb., to a price range of from \$0.90 to \$2.50 per lb. depending on the type of pigment.

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Definitions

Luminescence, as the term is generally defined, is the ability of a substance (natural or processed) to absorb radiant invisible energy and, after converting it to a longer wave length, to emit the energy as visible light. The radiant energy is provided by the activation of a light source in the short wave length visible, or the near ultraviolet,[1] spectral range. It is then converted and re-emitted over the visible spectral range. There are two types of luminescent pigments: 1) fluorescent and 2) phosphorescent.

Fluorescent pigments

Fluorescent pigments include all those that emit radiant visible energy only during the time of activation.[2] These materials have no useful afterglow. The most useful fluorescent pigments now available are zinc sulfides, and combinations of zinc and cadmium sulfides. These pigments are in themselves quite stable under ordinary moisture conditions. When incorporated into the plastic product they should withstand practically any exposure to black light. However, under certain conditions they may darken in sunlight. Severe acid conditions or the presence of heavy

[1] Ultraviolet light lies at the violet end of the spectrum outside the visible light range. Near ultraviolet contains some visible light.
[2] Activation is the process of absorbing radiant energy from a light source of short wave length and of converting such energy into visible light.

1—These dials and calculators, imprinted with luminescent pigments, were photographed under ordinary light. 2—The same instruments here were photographed while the luminescent pigments were being activated by an ultraviolet light

ALL PHOTOS, COURTESY NEW JERSEY ZINC CO.

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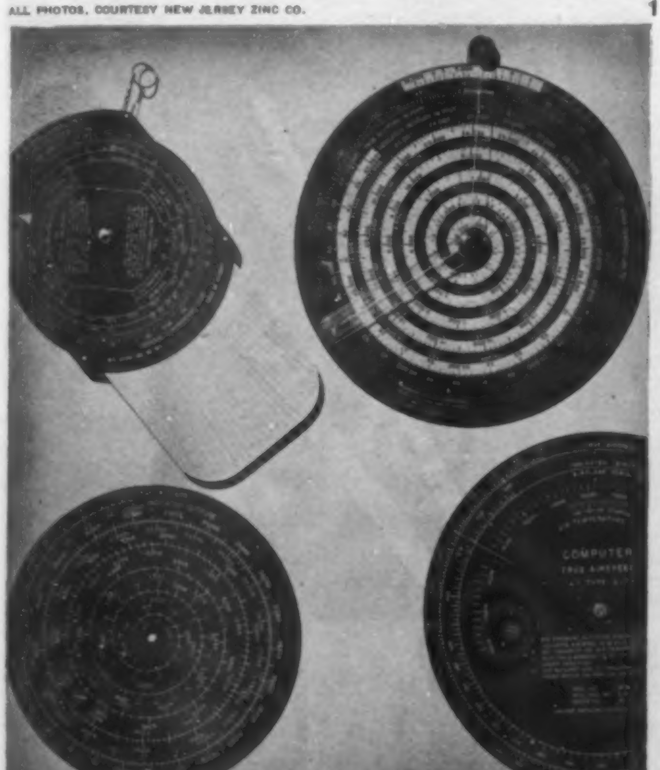

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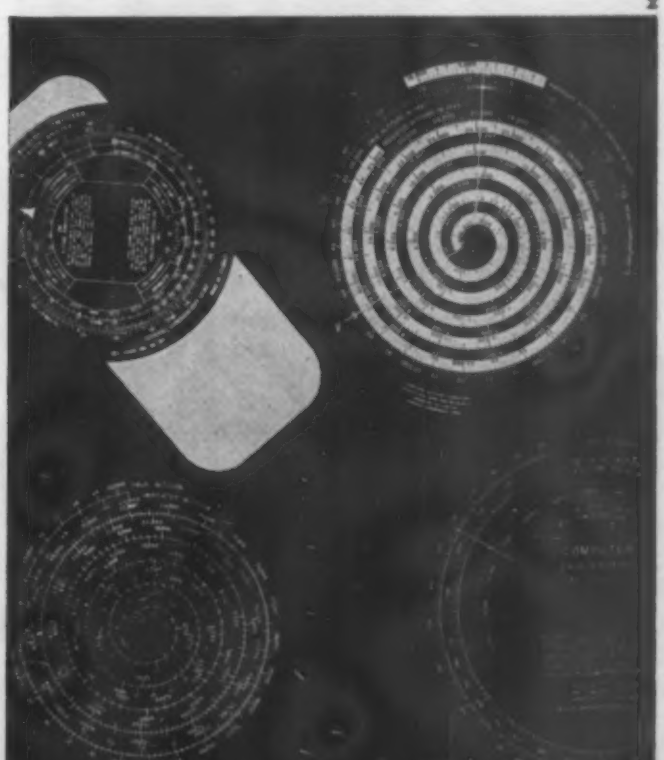


metals such as lead, iron or cobalt, may prove detrimental and affect the fluorescent intensity.

Fluorescent pigments are similar to ordinary pigments in their particle size structure—the average size being from 0.5 to 1.0 micron.[3] The fluorescent colors include various yellows, green, blue, red, orange and orange-yellow. The yellows and green have the brightest fluorescent intensity.

Phosphorescent pigments

Unlike the fluorescent pigments, phosphorescent pigments emit visible radiant energy for varying periods after activation ceases. Consequently these pigments have useful afterglow lasting for a period varying from a few minutes to several hours. It is probable that the phosphorescent pigments offer the greatest potential for postwar plastic luminescent applications since they are activated by either visible or ultraviolet light and they have useful afterglow characteristics.

The phosphorescent pigments most generally employed at the present time are crystalline forms of zinc, cadmium, calcium and strontium sulfides. Varying combinations of zinc and cadmium sulfides, and of calcium and strontium sulfides, often are used. The particle size of phosphorescent pigments ranges from 5 to 20 microns. They are, therefore, coarse in texture and cannot be subjected to extensive grinding. Any severe mechanical work done on the pigments causes a loss in the phosphorescent characteristics. Phosphorescence, however, is not affected permanently by heat or cold although there is a definite increase in length of afterglow under lower temperature conditions.

A minute after activation ceases, zinc sulfide pigments probably have an intensity of phosphorescence of about 100 microlamberts.[4] Within 50 min. that intensity decreases to 0.5–0.7 microlambert. The new, improved strontium and calcium sulfides have an initial brightness level comparable with the zinc sulfide, but the afterglow is of longer duration (Fig. 5).

It is rather difficult to say at what point on the decay curve the phosphorescent brightness of a pigment reaches a level where it is of no value. In pitch black darkness most phosphorescent materials are visible at close range to a dark-adapted eye[5] 24 hr. after being activated. These are rather extreme conditions however, and it seems of more practical value to say that the useful afterglow ends when the phosphorescent brightness reaches a level of 0.2 microlambert. This criterion has been used in arriving at the "useful afterglow" period given in the accompanying table. Color range of phosphorescent pigments at present includes violet, bluish-green, green and orange-yellow.

Activating light sources

A suitable light source is required for the proper use of luminescent pigmented products. Generally the fluorescent pigments need an ultraviolet, or so-called "black" light, which with suitable nickel oxide filters, excludes most of the visible light. High pressure mercury arc lamps, argon glow lamps and fluorescent lamps are generally used though an ordinary tungsten filament lamp equipped with a proper nickel oxide glass filter is a satisfactory light source. War demands have brought out improved black lights in a wide range of style and price. When used only for their after-

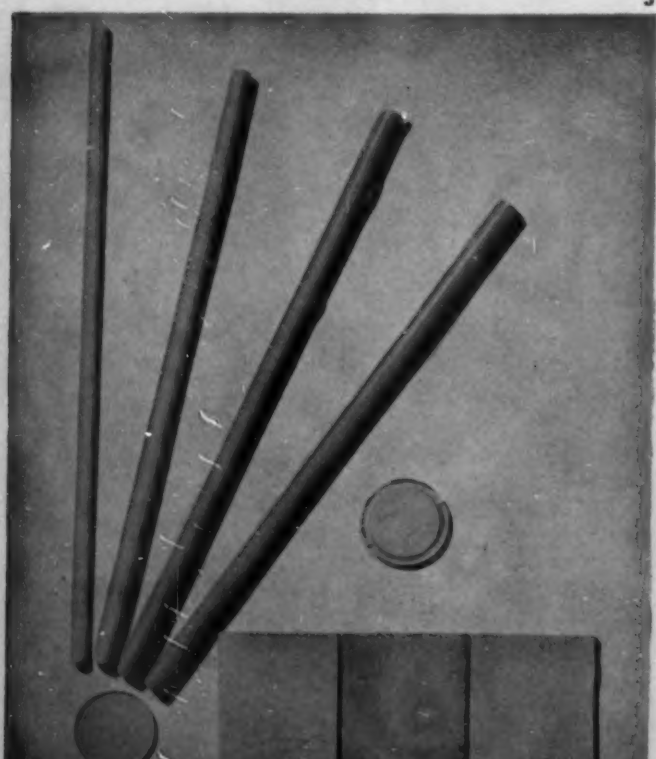
[3] A micron equals one 39 millionth of an in. (approx.).

[4] A microlambert is equal to the brightness of a perfectly diffusing and completely reflecting surface illuminated by a source of one candlepower placed at a distance of 10 meters (approximately 32.8 ft.). One foot candle (one candlepower at a distance of one foot) equals 1076 microlamberts.

[5] According to the estimates of scientists, dark-adapted eyes are from 50,000 to 100,000 times as sensitive to light as daylight-adapted eyes.

3—Under ordinary light these rods, sheets and discs give no indication that they are luminescent plastic. 4—The after-dark "glow" of these items suggests their use as switch plates, stair-riser markers and identification signs

3



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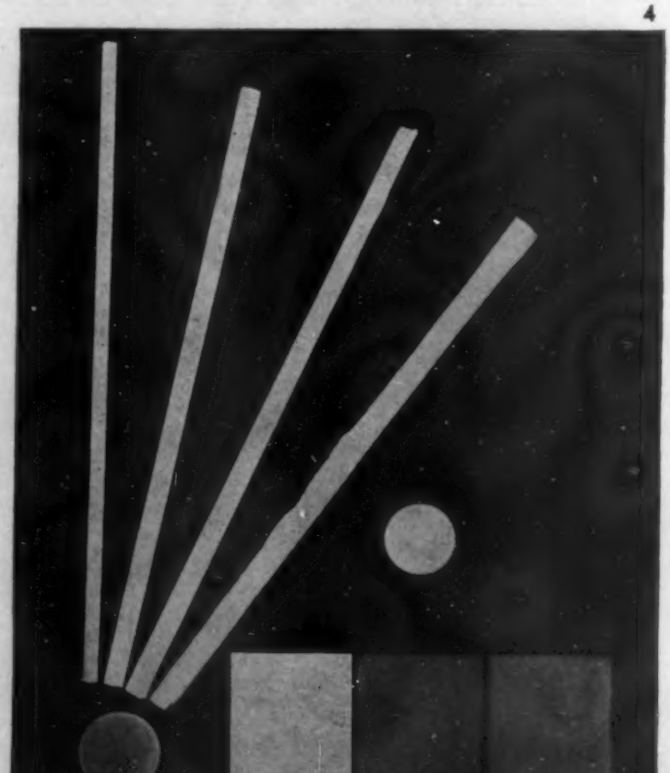

glow properties, phosphorescent pigments may be activated by an incandescent light bulb, a photoflood lamp or sunlight. If the fluorescent characteristics are to be utilized, a black light must be used.

Response to activation requires from a few seconds to a minute or more depending upon the intensity of the light source and the type of phosphorescent material being activated. In general the greater the lag period before decay of phosphorescence, the longer the time that is required for activation. In other words, the calcium and strontium sulfides require relatively much longer time of activation than do the zinc and cadmium sulfides.

Conditions of Manufacture

Luminescent pigments are manufactured under controlled conditions in which purity is especially important. The various sulfides are treated with a small amount of a metallic activator and then heated to a high temperature. Only the purest of sulfides and other ingredients can be used, and plant conditions of temperature control and cleanliness must be exacting. It is important that the user of luminescent pigments also take certain precautions in the compounding of these materials in plastics. Exposure to acidic conditions, moisture and certain degrading elements such as lead, iron and cobalt should be avoided with certain types of luminescent pigments. With these restrictions the processor should have no trouble in producing satisfactory luminescent products. (Note: Cadmium-bearing pigments are critical materials and are available at present only for military end uses and must be accompanied by a preference rating and the usual required information.)

Plastic applications

The following suggested applications are but a few of the possible uses of luminescent pigments in plastics:

Advertising.—Name plates, trade-marks, permanent signs, novelties and display material. (*Please turn to page 182*)

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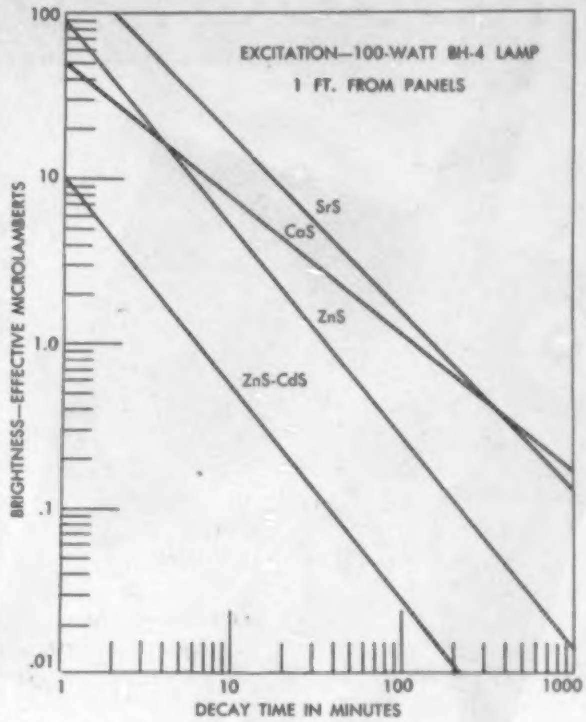

DRAWING, COURTESY NEW JERSEY ZINC CO.

5—*Decay curves of phosphorescent pigments show length of afterglow of 4 pigments and loss in brilliance over a period of time. (Practical brightness level usually made beginning 1 min. after activating is extinguished)*

TABLE I.—CHARACTERISTICS OF LUMINESCENT PIGMENTS

Pigment	*Luminescent colors*	*Particle size*	*Intensity of luminescence*	*Useful afterglow*	*Durability*	*Activating light source*
FLOURESCENT:						
Zinc sulfide	yellowish-green, orange-red, orange-yellow, light blue	Normal pigment fineness	Brilliant	No useful afterglow	Exceptionally stable	Ultraviolet (black) light
Zinc and cadmium sulfides (combined)	Orange-yellow, yellow, red, orange, brilliant yellow	Normal pigment fineness	High	No useful afterglow	Good	Ultraviolet (black) light
PHOSPHORESCENT:						
Zinc sulfide	Green	Coarse crystalline to medium fineness	High	Short (30–120 min.)	Stable under normal exposure	Visible or black light
Zinc and cadmium sulfides (combined)	Orange-yellow	Relatively coarse	High	Short (15–30 min.)	Stable under normal exposure	Visible or black light
Calcium and strontium sulfides (combined)	Violet	Relatively coarse	Low	Relatively long (10–12 hr.)	Sensitive to moisture*	Visible or black light
Strontium and calcium sulfides (combined)	Greenish blue	Relatively coarse	Medium	Relatively long (7–10 hr.)	Very sensitive to moisture*	Visible or black light

* Should be protected against the elements by a coating of a transparent plastic.

PRODUCT DEVELOPMENT

1

THIS CENTER PUNCH WITH A BELL CAP OF TRANSparent acrylic (Fig. 1) provides an accurate method of locating the exact center of a hole to be center punched and permits a drill point to be started at an exact 90° angle to the work. Previous to the development of this unit for aircraft production, the aligning of the punch to the work was done entirely by the unaided eye of the worker in conjunction with a center punch held and guided by his hand.

The center punch of this new tool extends through the apex of the transparent cone, which is equipped with a spring to hold the punch in an extended outward position. The transparency of the cone-shaped locator allows the point of the punch to be visible at all times. The bell cap is so designed that it rests flat on the surface of the work.

The principle of this cap also is being applied to electric hand drills and pneumatic hand riveters and squeezers. In these applications the bell is resiliently mounted for longitudinal movement only, on the frame of the tool.

Credits—Material: Plexiglas. Fabricated by Curtiss-Wright Corp.

PICKLING RACKS FABRICATED FROM VINYLIDene chloride pipe and rod (Fig. 2) are proving highly successful in the chemical treatment of many metals such as magnesium, to protect their surface from oxidation. Since the pickling bath is highly corrosive, wooden or metal racks have proved unsatisfactory due to contamination of the baths and a severe deterioration encountered in the racks themselves. Whereas racks formed of vinylidene chloride pipes and rods which have been welded together, have shown no indications of physical deterioration after 6 months in service, the average life of wooden racks is one month.

Credits—Material: Saran. Fabricated by Dow Chemical Co.

2

THIS REDESIGNED SURFACE PYROMETER (FIG. 3) used for the accurate and rapid determination of the temperature of flat and curved surfaces, offers numerous improvements over the former aluminum model. Not only has this new instrument a better weight distribution due to the position and design of the handle, but readings are easier to take because of the larger dial and the curved acrylic window.

The housing of this pyrometer is compression molded on a 300-ton press of a black, semi-impact phenol-formaldehyde material. A split top follower mold makes the handle hollow. Assembly holes are drilled just prior to assembly. In addition to being light in weight, this phenolic housing is easy to clean and keep clean—an advantage for instruments frequently used in dirty, dusty plants. The housing which finally was selected in preference to two other proposed designs, has fewer parts—thus offering a saving in assembly costs.

Credits—Material: Bakelite. Designed by Johnson, Cushing, Nevell. Molded by Boonton Molding Co. for Cambridge Instrument Co.

3

BEFORE THE WAR, PAPER PERFORATORS CONTAINED approximately 2 lb. of steel. When WPB restricted the amount of metal used in these devices to 8 oz., development work was begun on a cellulose acetate unit (Fig. 4) capable of perforating paper stock ranging from one thin sheet of tissue to 15 sheets of 20-lb. Bond. To insure the correct position of the two perforations with relation to the top and bottom edges of the paper, a small ruler was included.

Except for a 2-oz. metal frame which is molded as an integral part of the punch base, all 7 parts of this perforator are injection molded of cellulose acetate. The base and handle are molded in a single, 2-cavity mold—one cavity for each piece. The 2 shoulders, ruler and punch cover are produced in one, 4-cavity die. Before assembly, a battery of drill presses cut the fulcrum points which are located by precision jigs, to insure facile raising and lowering of the punch handle. Then base holes are drilled and tapped.

Credits—Material: Plastacele. Molded by Gemloid Corp. for J. Cogert & Co. and Sal Metal Products Co.

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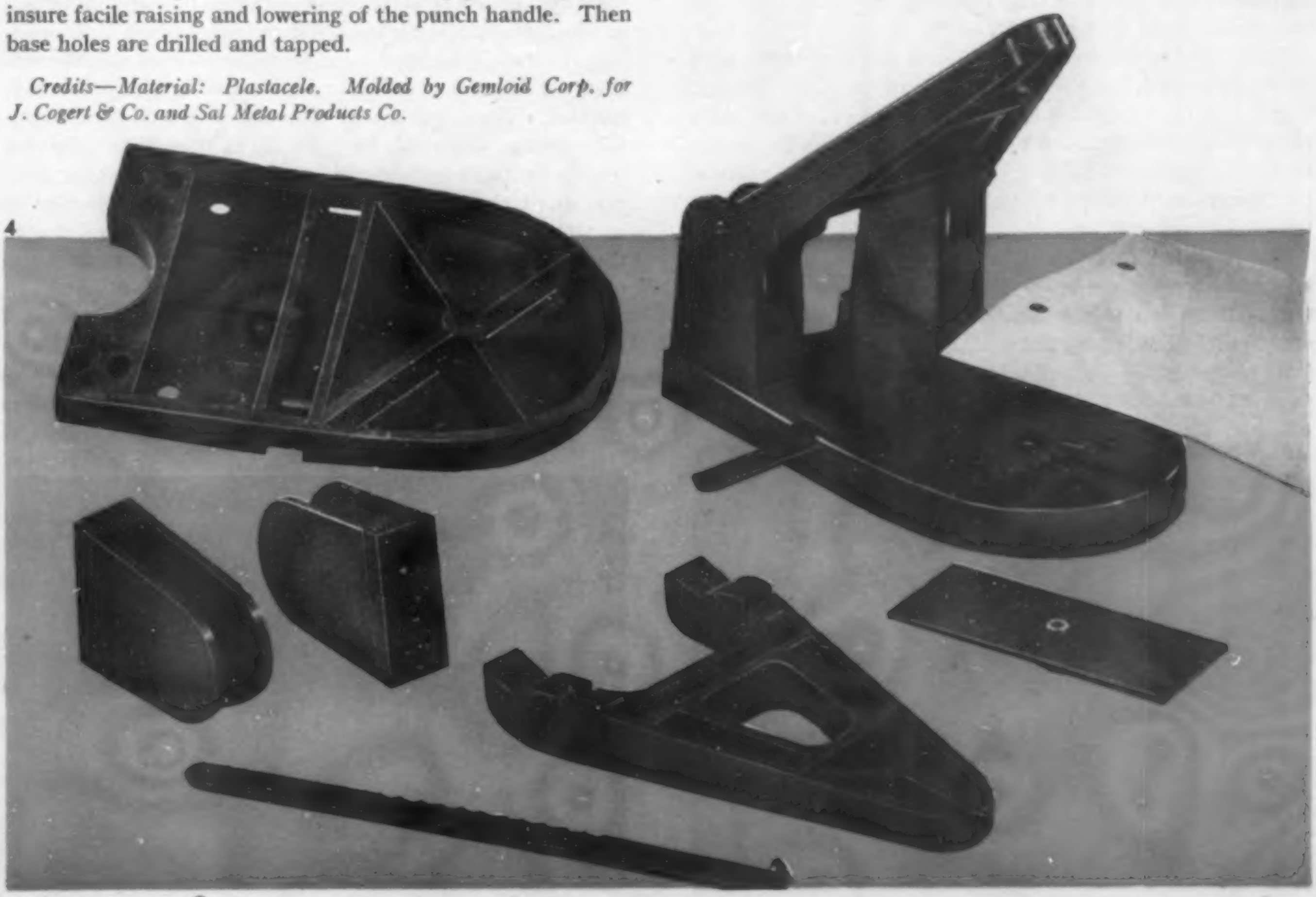

Every soldier who goes into action is supplied with sulfadiazine pills packed in boxes which are encased in moisture-resistant, gasproof envelopes. The lid of the acetyl cellulose acetate container is designed to open easily so that even a badly wounded man denied the use of his arms can quickly slide it open with his teeth

Pill boxes for our soldiers

FOR some time past the Upjohn Company has been at work on a difficult problem, that of developing pill containers for use of our fighting men. The Medical Department of our armed forces had decided that each soldier should be provided with his personal supply of the new lifesaving drug, sulfadiazine, and the task of developing a suitable plastic container fell to the lot of this large drug company in the correct packaging of their product.

Many pill boxes have been developed and many have been successfully used, but the requirements of the Army Medical Corps were rigid. So it has come about that even the lowly pill box has been improved by the Army's passion for perfection in equipping its fighting men; and as a result, postwar pills for civilians will probably be more conveniently and attractively packaged.

The final design of this tight acetyl cellulose acetate container which was approved by the Army, consisted of a sliding top molded with undercut flanges on both sides, which in turn engage with projections extending along the top edges of both sides of the box proper. This lower portion of the unit was designed with eight round depressions that form separate compartments for each pill—a construction which serves to keep the tablets apart and prevents them from crumbling. The cover is constructed to fit snugly but at the same time slide easily in either direction so that a wounded man who might be unable to use his hands, can open it with his teeth.

Figure 1 shows the molded pill box together with the heat-sealed envelopes of kraft paper, cellulose film and metal foil in which the box is packed. These packages are both moisture-resistant and gasproof, yet at the same time easily opened. Figure 2 demonstrates the ease with which this container is handled. When a soldier is wounded, he merely tears open the envelope and slides back the lid of the pill box, making readily available two or more tablets according to the position in which the lid is stopped. The high acetyl cellulose acetate material from which this box is molded, coupled with the design, make this unit so strong that a soldier can stamp on it without crushing either the box or the tablets.

A good deal of time usually elapses between the approval of a new plastic part and actual full-scale production. In this case, time was so very vital that nearly all records for tool production were surpassed. The molding company states

ALL PHOTOS, COURTESY MONSANTO CHEMICAL CO

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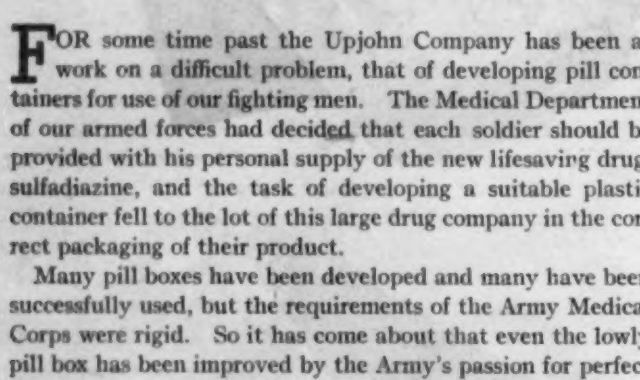

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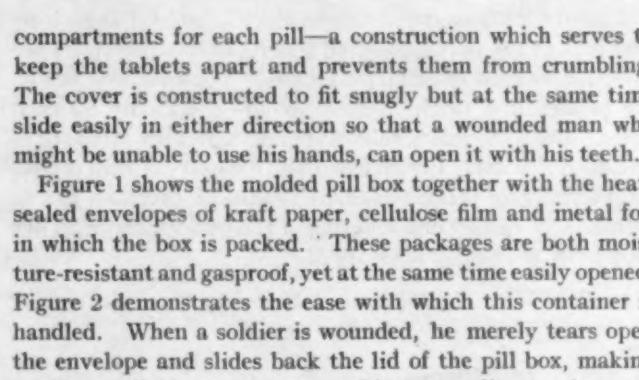

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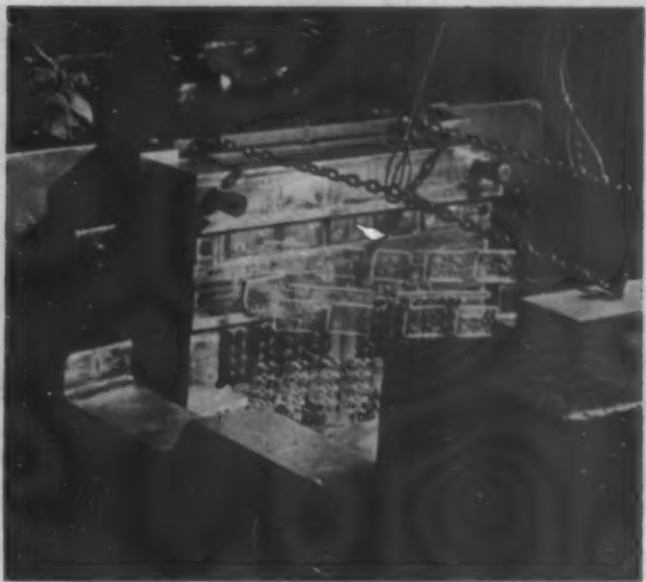

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2—A plastic pill box filled with sulfadiazine tablets, and envelopes in which the containers are encased. 3—These containers are so tough that they will not crush beneath the weight of a man. 4—Sixteen complete boxes are molded from one shot. 5—Every 20 sec. a sprue of boxes is removed from the press. 6—The raised lettering on the box lids is printed in a bright red. While one girl arranges the lids in a row, another inks them with a hand roller. 7—The freshly printed lids are carried down a short conveyor belt under infrared lamps

that within five weeks after the contract for these parts was signed, mold designs were drawn up, checked and work was completed on the first of three 32-cavity injection molds. Parts were immediately produced, approved and molding was began. Three weeks later, a second mold came into production. If these had been small 2- or 4-cavity molds with little machining or fitting necessary, this five-week period would not have been so astounding; but when the complete shot shown in Fig. 4 is carefully inspected, the great care necessary in processing this tool is immediately apparent. Perfect alignment of plugs and cavities had to be obtained not only because of the part design but also because of the very thin wall section. Any misalignment, of course, would have resulted in "molding through." [Note: In Fig. 4, this shot of boxes has been molded from a white opaque material so that the outlines of the parts can be more clearly discerned.]

One of the 32-cavity setups is shown in Fig. 5, with the operator just removing a shot which has been molded in the standard-production clear material. The complete cycle is approximately 20 sec., resulting in an output of 180 shots per hour. This speed of production adds up to the following interesting figures: one 32-cavity mold will produce 22,000 complete pill boxes per 8-hour shift or 66,000 per day. Inasmuch as this company is operating three of these molds, total production amounts to approximately 200,000 complete pill boxes per 24-hour day. So far as volume of material is concerned, this high-speed production chews up in the neighborhood of 4000 lb. of high acetyl acetate per day.

One of the more interesting and difficult problems that arose on this job was that of printing the raised lettering on the box covers. The name "Upjohn" and the directions for opening the box are molded on the cover, but after the molds were built and in operation it was decided the lettering should be colored for increased legibility. Several mechanical printing methods were tried including the use of Photolith machines and the latest type of automatic printers. The Photolith machines, however, required a crew of seven girls to operate, the costs were high and the results, (*Please turn to page 182*)

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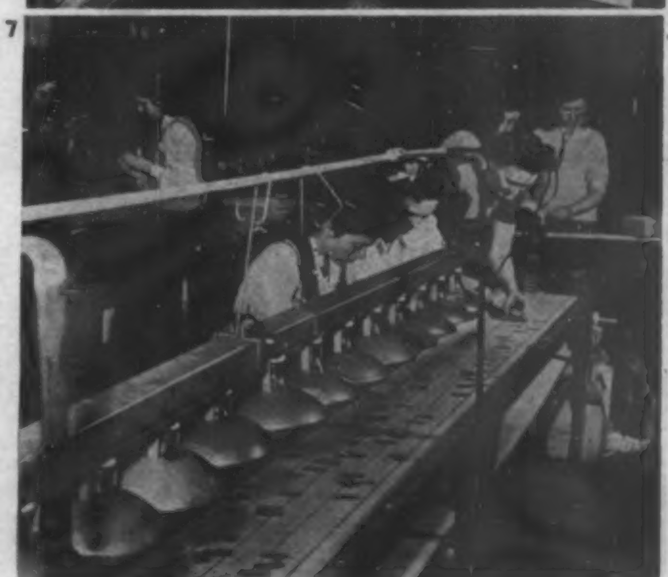

Looking forward

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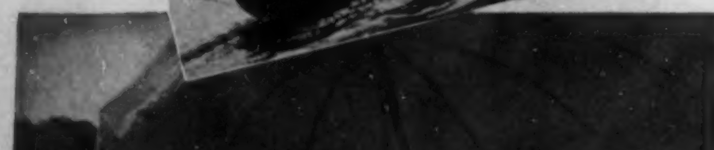
Since the outbreak of war, the editorial pages of Modern Plastics *have been devoted to descriptions of the applications of plastics to military and war production items. Now American industry has another task to perform in addition to that of winning the war—it must prepare for the coming postwar era. To assist in plans for this conversion from a war to a peace economy,* Modern Plastics *offers this article as one of a series dealing with possible future applications of plastics to civilian goods and to items of industrial equipment. Another article of this type, "The future of plastics in aviation," appeared in the December issue of the magazine.*



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ALL PHOTOS, COURTESY E. I. DU PONT DE NEMOURS & CO., INC.

At present, nylon is allocated by the government chiefly for parachutes, cargo 'chutes, airplane tire cords, glider tow ropes, sewing thread, wire insulation, mountain troop tents and surgical sutures. However, the very qualities which have placed this plastic on the list of critical war materials suggest the possibility of its use after the war in a wide variety of consumer goods.

In the field of sports, nylon's resistance to damage from mildew, its elasticity and quick-drying characteristics should render it of use in numerous items of athletic equipment. An example of such an application, is the sail cloth shown in the spinnaker in Fig. 1. In this case the smooth surface of the material results in less skin friction and wind penetration is reduced because the yarn can be set or calendered flat. In addition, the light weight of this sail cloth—one-half that of a comparable cotton sail—makes it easy to handle in all types of weather.

Rattan seats on garden chairs (Fig. 2) are suggestive of many new applications of nylon in furniture. The strips of plastic which form these seats seem particularly suited to subway or bus seats because of their smooth, easy-to-clean surface. Nylon's high degree of weather resistance especially recommends it for use out-of-doors, and it is understood to withstand heat up to 275° F. under load, without softening. The material's toughness is of special value in this application where sections must be thin and strength great.

In the field of postwar fashion nylon would seem to lend itself to use in a round-the-clock, rain-or-shine schedule. No one will regret rainy days when raincoats such as the one shown in Fig. 3 are available for civilian wear. The fabric used for this coat, turban and umbrella, which was woven experimentally before the war, combines sturdiness with a feather-light weight for flattering fit and comfort.

For evening or afternoon wear there probably will be a wide variety of fabrics of which the marquisette shown in Fig. 4 is but one example. In this instance fine draping qualities and unusual strength are combined with a smooth, non-absorbent surface which tends to keep the dress fresh-looking for long periods. The permanent setting of the nylon cloth after knitting or weaving, causes the garment to retain its shape and remain unusually free of wrinkle, even through laundry and cleaning work.

Characteristic of the many knit garments, which may be made of spun nylon, is this soft, long-sleeved sweater (Fig. 5). Socks, undergarments, fleece coats and numerous other woven and knitted wool-like articles of clothing may well be produced from short lengths of this synthetic fiber after it is spun into soft, fuzzy threads.

These are but a few of many possible civilian uses for nylon in the postwar period. The list also might include quick-drying, figure-controlling bathing suits and foundation garments. Straw-like material made from single strands and fabric coated with nylon to produce non-scuff leather effects may be used for postwar shoes. This plastic may be used as strong netting for curtains that need no ironing or stretching, for non-sag lace and sturdy spun twill. Pleated garments such as frilly neckwear and boxed skirts, if made of nylon, would have the advantage of withstanding washing and cleaning without need for repleating. The plastic can be used as a yarn, coating, transparent film and monofilament.

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PLASTICS

3

1 Various Canadian shell-loading plants employ this portable light to minimize the danger of overheating or sparking during the inspection of the shell cases. While the transparent Lucite rod which is attached to a handle of soft, non-sparking metal gives a concentrated shadowless illumination, it does not conduct heat readily and therefore does not generate dangerous temperatures

2 The Army Air Forces now are using Tenite pellets in sand-blasting equipment to remove carbon from piston walls and from narrow piston ring grooves. The material, designated as Tenite I in granulated form, is 1/16 of an in. in size with an intermixture of smaller sizes. When the pellets are blown against the piston sides and ring grooves the carbon is knocked off by force and the surface given a polish with abrasion of the metal or pulverization of the pellets. The spont pellets fall through an open bar grate into the hopper whence they are recirculated. One charge of these pellets may be used effectively for about 3 days

4

3 In sub-zero weather, storage batteries deliver only 1/4 as much power as at normal temperatures. To overcome this situation, heaters that maintain the temperature at approximately 70° F. now are being installed between batteries or built in. These heating units consist of resistance grids of nickel-chromium ribbon imbedded in acid-proof Micarta molded under high pressure and heat

4 Magnifying lenses have become as essential to the industrial workers as to medical and laboratory men. This new headband set of magnifiers, which is manufactured by May Manufacturing Co., helps to meet this increased demand by eliminating the need for manufacturing the frames in various eye sizes and pupilary distances. The Lumarith loupe permits an ingenious type of punching which provides 8 different head size adjustments. In addition the band is considerably lighter in weight and more comfortable to the touch than previous models. The unit is

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IN REVIEW

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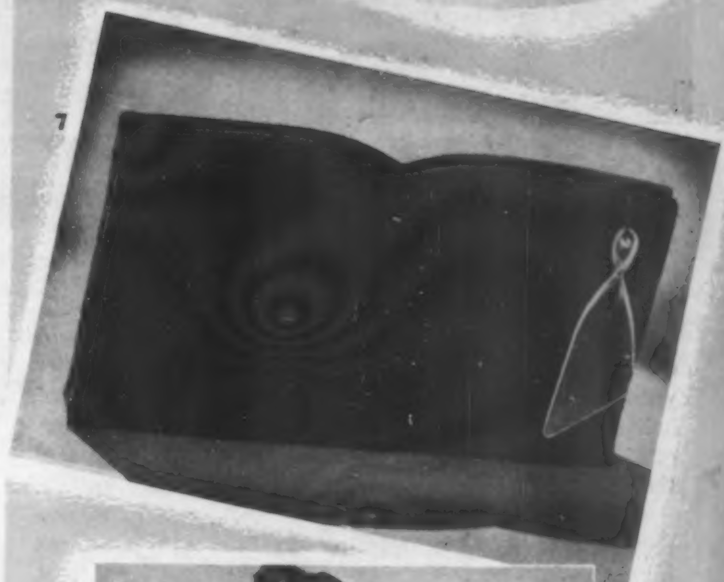
equipped with a vision conversion adjustor and has been so designed that it can be worn comfortably over glasses if necessary



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5 To provide full visibility while assuring protection from dangerous breakage and flying particles, the powerhouse at the Naval Academy in Annapolis is equipped with windows of reinforced Vuelite. The glazing material consists of two sheets of .060-in. cellulose acetate sheet laminated with a 6-mesh, .023-in. wire

6 This rapid-heating explosive rivet gun with a handle molded of machined commercial Micarta, operates on the principle of passing a low voltage and high current through two conducting loads terminating in a high resistance metal tip. Pressure on the trigger closes the circuit and causes the tip to heat almost instantly. The plastic handle of this tool, which was developed by Goodyear Aircraft Corp., insures high-impact strength and good dielectric properties. When a rivet is detonated, the trigger is released and the operation is repeated on the next rivet. Rapid radiation results in a speedy cooling of the tip

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7 Among the newest fashions for the coming season are Corde handbags embroidered of Plexon yarns. Richfield-Vivona & Co., manufacturer of these purses, also uses plastics for closures. The zipper tab on this envelope handbag is fabricated of transparent Lucite

8 Smocks, sleeve guards and gloves of Resistoflex Compar have been developed to combat dermatitis and follicultis caused by industrial worker's skin coming in contact with sulfur-base cutting oils, paints, thinners, cleaning and degreasing compounds and other organic solvents. These protective coverings not only are oil- and solvent-proof but have a high resistance to both tear and abrasion. They are so light in weight that they in no way add to the worker's fatigue

TRAINING INSTRUMENTS FOR NAVIGATORS*

As a result of our tremendous aircraft expansion program especially on medium and heavy bombers—large numbers of trained navigators are required to plot the course of each bomber to its objectives and back to its base. In former years the training of these men was principally a matter of individual instruction in background theory and in the use of highly specialized navigational instruments. But today the need for expert navigators is so great that such instruction methods are not fast enough. In addition, this training requires more competent instructors than can be spared from the fighting fronts. Consequently, instructors must handle large classes with as many as 75 or 100 students, and compress the essential information into a concentrated course of instruction.

To facilitate this type of mass instruction, large-scale models of essential navigational instruments are being used to excellent advantage. One such new device is a huge computer, 25 times normal size. The computer is a combination slide rule and revolving disc used by the navigator in plotting his plane's position. In constructing this device, skilled craftsmen of the Synthetic Training Aids Laboratory at Mather Field, Mills, Calif., took advantage of the transparency and good machining qualities of acrylic resins. While an instructor demonstrates with the oversize computer, student navigators follow each step of a calculation with their own small computers.

Acrylate resin has been employed in the construction of similar visual training aids used in other camps and training stations throughout the United States. For example, at Hondo Field, Texas, a sliding "key to the universe" is in use. This device consists of a large sheet of acrylic superimposed on a flat map of the world. Painted on the transparent plastic sheet are the star symbols used in celestial navigation and curves that show the stars' apparent orbits in the sky. By sliding the transparent window from side to side across the map, the instructor easily shows the various positions these celestial bodies can have with reference to the earth. The light, strong, easy to handle and non-distorting qualities of this plastic assure maximum light transmission which renders the workings of this unit clearly visible to the entire class.

A third device designed to simplify and to speed the instruction of navigators was built by the Instrument and Navigation Branch of the Army Air Forces Matériel Command at Wright Field. It consists of a hollow acrylic sphere on which are etched colored lines designating the various stars and chief constellations with which the navigator should be familiar.

A new celestial navigation instrument which combines a sextant for use during the day, and a quick means of determining true north, sun time, latitude, great circle course and direction, has been designed recently especially for use in life rafts. Made entirely of corrosion-proof acrylic and weighing about one pound, the instrument will float in water. At night it is visible for a distance of 25 feet.

Now under consideration by the services, the instrument combines a miniature of the celestial sphere with names and precise locations of the 22 navigational stars, and a world globe with all coordinates. It can reproduce the movements of all celestial bodies used in navigation exactly as they are seen from any point on the earth's surface. With proper settings and with the instrument level, rays of light from the sun are passed upon the world globe from sunrise to sunset. While in this position, the altitude and "azimuth" (angle of sun north or south along the horizon) may be

* Rohm & Haas Co.

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measured. The use of this celestial sphere on a life raft eliminates the need for a nautical almanac, sextant, compass and involved calculations to determine position.

F. H. Hagner of San Antonio, Texas, the inventor of this new celestial navigational instrument, has an impressive record of accomplishment in the development of scientific navigation devices, many of which now are being widely used by the U. S. Army and Navy. Apart from its use on life rafts, this device is helping to simplify the teaching of celestial navigation. According to Prof. Charles O. Roth, Jr., of New York's famous Hayden Planetarium and Newark College of Engineering, its use enables a student to carry in his mind a clear picture of what happens every 24 hours of the day. This is important since the foundation of nautical astronomy and celestial navigation is based on a clear understanding of the relative motion of the earth and the stars.

Credit—Material: Plexiglas.

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1—Use of this oversize model for instruction in the operation of a computer, obviates the need for individual demonstrations. 2—This transparent, sliding "key to the universe" device is used by military instructors to show the various positions that celestial bodies can have with reference to the earth. 3—Chief constellations are etched on the surface of this celestial sphere and filled with color. 4—The globe of this celestial navigation instrument is lifted from its transparent base and held in proper position to determine True North latitude and course direction without the aid of a nautical almanac, sextant or any involved calculations

A new turn to the spigot

Colorful plastics faucets add to the attractiveness of the modern soft-drink bar

WHEN a Philadelphia doctor first introduced carbonated water to this country in 1807 as a medicinal tonic, he little guessed that he was giving the first impetus to what was to become the great American soft drink industry. Not in his wildest dreams could he have imagined that some day glasses would be filled with sweet, fizzing concoctions by the twist of a spigot.

Since those early beginnings native genius has found a thousand ways not only to increase production and raise the hygienic standards and attractiveness of the oldtime "tonics," but also to make life easier for those who serve them. One laborsaver is an all-plastic spigot widely used on commercial stone barrels, in restaurants and soda fountains. Its possible uses extend over into the field of portable containers such as canvas water coolers for field use where lightness and durability are important considerations.

In selecting a material from which to mold these spigots several peculiar conditions had to be considered. A medium soft grade of plastic was indicated, capable of withstanding cold without becoming brittle. It also was essential that the material be inert to all food acids and have low moisture absorption. Another requirement was that the plastic should not impart a flavor to any beverage with which it came in contact. Since two plastic nuts are used in the assembly, the material must have a long cold flow so that the nuts will not shrink and need frequent tightening. Cellulose acetate butyrate was chosen as combining all the necessary properties.

Since the 4 pieces comprising the assembly—body, valve, valve retainer nut and spigot retainer nut—are treated almost as blanks and much of the work is done after they are released from the mold, the actual molding operation is comparatively simple. The parts for two complete injection-molded spigots are formed at every shot and the molding cycle runs between 50 and 55 seconds. In addition to its primary function of allowing the relatively heavy sections in the spigot body to set firmly, this fairly long cycle has further advantages. Because of the comparatively highly heated state of the material, the molder is able to use a standard 6-oz. machine for a shot which, complete with sprue and runners, weighs nearly $7^1/_2$ ounces. The fact that the material has time to become thoroughly plastified before it is molded makes possible the production of parts of unusual density and toughness. Furthermore, although large gates are used, they are held less responsible for the absence of weld marks in these moldings than is the highly plasticized state of the plastic during injection and the use of a warm mold.

The "blanks" are molded in an 8-cavity die. The parts and cavities are so arranged that only one set of cores need be withdrawn, an operation which is accomplished by means of a hand-operated rack and pinion. All other openings are formed by molding around pins (*Please turn to page 184*)

PLASTICS ENGINEERING

F. B. STANLEY, Engineering Editor

Laminated bomb burster tube

CAMOUFLAGE in warfare takes many and varied forms. Bizarre and fantastic paint designs are used to conceal ships at sea. Cloth and netting covered with foliage gathered from the surrounding country serve to conceal not only equipment but the fighting men themselves. In this type of camouflage the objects are not actually hidden but are blended into their surroundings so that it becomes almost impossible to distinguish the outline of any of these so-called camouflaged units.

Another type of camouflage—one which actually conceals equipment and men—makes use of a heavy, dense smoke. Press reports have praised the effective concealment given our landing forces in the European theater of war and expressed the opinion that casualities were much reduced because of the efficiency with which various types of smoke screens were used to conceal the landing operations. To achieve this high degree of effectiveness in laying down smoke screens, the Armed Services now employ bombs loaded with white phosphorus.

When these white phosphorus smoke bombs were still in the development stage it was found that they must burst in their entirety when detonated if maximum despersion of the bomb contents was to be obtained. To reach this efficiency a bomb was designed, Fig. 4, with a burster tube extending through the entire length of the bomb. This burster tube, which is loaded with tetryl, first was manufactured from aluminum tubing. Although the scarcity of aluminum had not made itself felt at the time this bomb was put into large scale production, the limited facilities available for the production of aluminum seamless tubing made it imperative

A literal "lifesaver" for our troops, this dense cloud resulted a second after phosphorus smoke bombs exploded to provide a screen for advancing troops

PHOTO, WORLD WIDE PHOTOS

PHOTO, COURTESY BAKELITE CORP.

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that another method of manufacture be developed for the burster tube.

Early development work to produce a satisfactory replacement for this tube was initiated by the Cincinnati Ordnance District. Headed by Major E. Norton, Major Stanley E. Hess and Captain E. Olsen, under the personal direction of Colonel F. A. McMahon, the research was directed toward the possibility of producing a satisfactory laminated tube. After three months of test work carried on by the Formica Insulation Co., with the cooperation of the Technical Division at Picatinny Arsenal, a suitable tube was approved and put into production at the Formica plant.

This tube, embodying all the necessary properties required by the specifications, is manufactured from a resin coated and impregnated paper—the combination coating and impregnating being performed in one operation. A roll of the paper is mounted at one end of the impregnating and baking equipment. In a continuous operation the paper is carried through a liquid resin bath, through rollers which are set to permit very accurate control of the weight of resin picked up, and through an oven with a temperature regulated so as to completely dry the material and advance the resin to a definite, specified stage. At stated intervals the laboratory technician cuts a sample swatch of resin impregnated paper which has passed through all operations. This swatch then is taken to the laboratory where the weight of resin "picked up" is carefully checked. This control assures uniformity of the raw material.

The next stage in the manufacture of the tube is known as the rolling operation. The setup of the rolling machine is shown in Fig. 2. The large roll of impregnated paper in

2—The operator pulls the impregnated paper forward in order to get sufficient slack to permit her to start the sheet rolling around the mandrel. The size of the roll of impregnated paper (lower foreground) eliminates frequent stoppage to replace an empty shaft with a full roll. 3—At the start of the rolling operations on a burster tube, the paper is slipped under the long mandrel which has been preheated on a steam platen and conveyed rapidly to the rolling machine on a conveyer. 4—A cross section view of a phosphorus smoke bomb that is used for camouflage purposes. The positions of the burster tube and well are indicated

PHOTO AND DRAWING, COURTESY FORMICA INSULATION CO.

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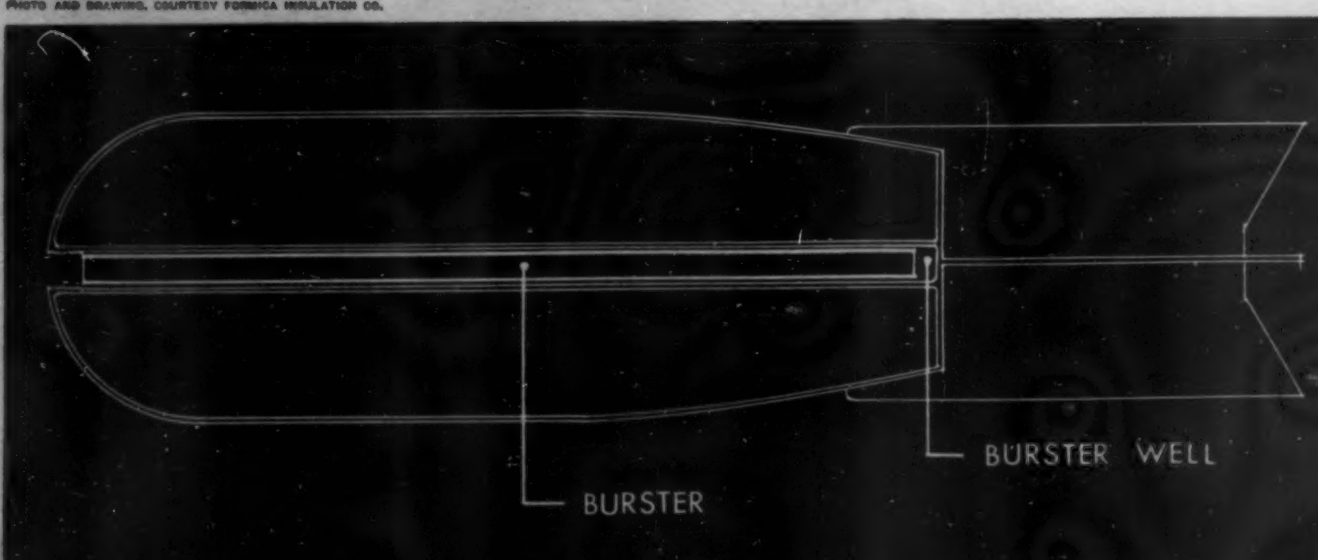

PHOTOS, COURTESY FORMICA INSULATION CO.

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5—The conveyor system not only carries heated mandrels to the tube rolling machine but it takes the rolled tubes to and from the oven. In the background is the conveyor used to carry the tubes through the oven. 6—After the tube is rolled to the desired thickness, the paper is cut off. 7—The burster tubes come from the ovens on this conveyor. Here they are being removed preparatory to finishing

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PHOTO, COURTESY BAKELITE CORP.

the lower foreground eliminates the need for frequent stoppage to replenish the paper supply and thus permits almost continuous rolling of the tube. Since a certain amount of slack in the paper is needed in order to start rolling the material around the mandrel, the operator first draws the paper forward (Fig. 2) and then slips it under the mandrel (Fig. 3). This mandrel is preheated on a steam plate and hurried to the tube-rolling machine on a conveyer, just prior to the start of rolling operations. The mandrel is power driven, and the material is pulled from its roll by reason of friction created by the pressure of two small rolls shown at the foreground in Fig. 3, and a large diameter steam-heated pressure roll shown at the left in Fig. 6. Before the start of the actual rolling operation, the large roller is brought forward until it is in contact with the rear of the mandrel. At the same time, the two small rollers are moved back so that they in turn press on the forward part of the mandrel. This action creates the friction and pressure required for the actual roll-forming of the tube. Figure 6 shows the rolling machine in the open position after the rolling operation has been completed.

So that the operator will know when the number of layers of paper needed for a burster tube has been rolled on the mandrel, a locating hole is pierced at a previously determined point in the paper before the rolling operation is started. When this locating hole comes in line with the straight edge shown just to the left of the large roller (Fig. 6), the operator cuts the paper off with a sharp knife and permits the rolling operation to continue until this excess material has been completely rolled. The tube and mandrel then are removed from the rolling machine, another heated mandrel mounted in their place and the operation repeated. The completed tube still mounted on the mandrel is placed immediately on a roller conveyer which carries it to the baking oven. The general setup for this operation can be seen in Fig. 5. The girl in the background is in the process of hanging a rolled tube and mandrel on the conveyer which will carry it through a baking oven. This oven is held at a temperature of 150° C., and the speed of the conveying system is such that it takes 90 min. for the tube to pass through the oven. This oven time is necessary in order to reduce the free phenol content of the tubes to a percentage satisfactory to Ordnance specifications. (*Please turn to next page*)

PHOTO, COURTESY FORMICA INSULATION CO.

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8—In this equipment, designed specially for removing the tube from the mandrel, the tube is held back by a circular stop (center) while the mandrel is withdrawn on the far side. 9—The cured tube is ground on a centerless grinder equipped with several streams of water to remove the products of the grinding operation. 10—The 2 ends of the tube are sawed in order to achieve proper length

After the tube and mandrel are taken from the oven (Fig. 7), the tube is removed from the mandrel by means of equipment (Figs. 6 and 13) designed specially for this operation. The jaws of the unit automatically grip one end of the mandrel. A circular stop which fits around the mandrel just back of the jaws of the disassembly device serves to hold back the tube when the mandrel is withdrawn from the burster. Power then is applied and the mandrel is drawn from the tube, leaving a perfectly smooth interior surface which is immediately gaged. A plug gage, ground to the minimum inside diameter that is permitted, is dropped through each tube. This inspection operation checks the entire length of the inside diameter and assures the fact that each burster when loaded will contain no less than the specified amount of tetryl. Removing oversize rejects at this point has a dual purpose. One, it segregates unusable parts and two, it saves finishing labor which would be wasted if these parts were permitted to go through the balance of the operations before gaging. In order to finish the outside of the tube, a centerless grinder is employed (Fig. 9). It is at this stage of manufacture that the tube is ground to a definite outside diameter and held to a tolerance of $\pm .005$ inch. The water necessary for this operation acts not only as a coolant but to remove the products of the grinding operation.

Following the finishing operation on the outside diameter, the tubes are cut to the required length by two hollow ground circular saws. Figure 10 shows the operator with a tube setup in the cutting jib. A careful check is given each one of these tubes—100 percent inspection is the order of the day and very close tolerances have been set up in the specifica-

PHOTOS, COURTESY BAKELITE CORP.

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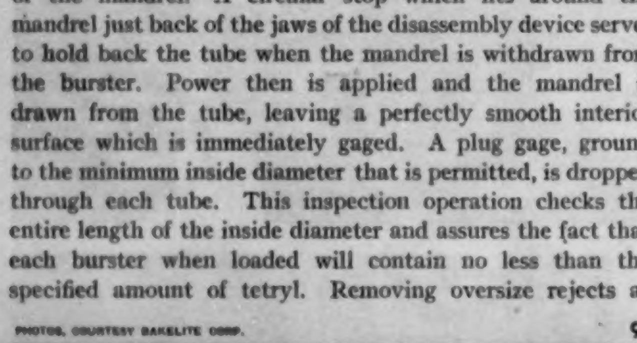

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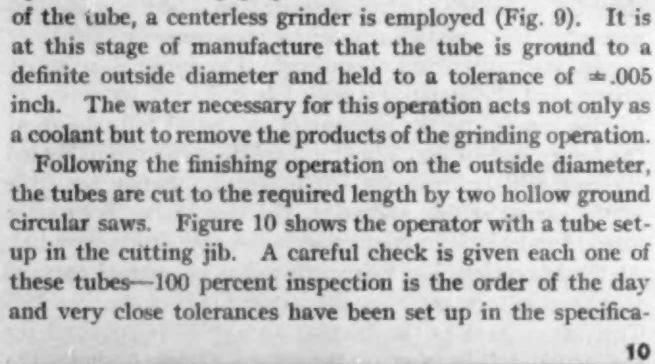

PHOTOS, COURTESY BAKELITE CORP.

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tions. An operator shown in Fig. 11, checks both the outside diameter which is held to ±.005 in. and the overall length which is held to ±.010 inch. Figure 12 shows the operator with a plug gage checking the inside diameter of the tube, which is held to a tolerance of +.005 in. − .000 in. One additional gaging operation is set up in this production.

The pictures that accompany the article have been used to give an idea as to the type of equipment necessary in the production of these tubes. The volume of equipment has not been shown.

With this equipment the company as of Dec. 1943 produced over 3,000,000 of these burster tubes. The company states that it has been advised that the laminated burster is much more efficient than the metal burster formerly used by our Armed Services. The success of the new tube is due to the fact that it bursts in its entirety when detonated while quite often a metal tube tore or ruptured in a certain area and therefore did not disperse the bomb contents over as large an area as was desired. Research on the use of this burster has continued until it now is used not only in smoke bombs, but in a new type of bomb. If gas warfare ever becomes a necessity this burster will be ready and waiting to increase the deadly effectiveness of gas bombs.

Again, we have found a plastic application which is not a substitute. While the tube admittedly was designed to conserve man- and machine-hours once it was produced it was found to be superior to the part that it replaced.

Credits—Resin: Bakelite. Manufactured by Formica Insulation Co. for U. S. Army Ordnance

13

***11**—The burster tubes are given several inspection tests before they are ready for shipment. Here the bursters are being checked for correct OD and length. **12**—The ID measurements of the tubes are checked by means of a plug gage. **13**—Another view of the core pulling device. The mandrel is being removed at the right and the tube at the left*

The AT-10 Trainer Plane owes much of its strength and durability to Plaskon Glue.

Plaskon Resin Glue is used in Navy's all-wood trainer plane . . . first of its kind.

Plaskon Resin Glue helps make these all-wood gliders strong, light, durable.

Plaskon Glue helps form bomber noses, entire fuselages, and fabric fillets.

A new gluing process*

by WILFRED GALLAY† and GERALD G. GRAHAM†

THIS paper describes in some detail a new method of gluing wood which has particular application in the assembly of relatively thick laminated timbers but which shows some possibilities also in the manufacture of plywood and in the lamination of thick sections of resin-impregnated fabric. The new development is outstanding in its simplicity and ease of operation since it requires virtually no new equipment or plant conversion and no specially trained personnel. The new method permits of hot gluing in a cold press and is to be sharply distinguished from high-frequency heating[1] from which it differs entirely in principle and over which it shows some definite advantages. This advance does not involve the use of a new adhesive per se. It utilizes existing synthetic resin glues in a novel fashion in order to obtain optimum results having regard for both quality and economy in manufacture.

In the present work a method was sought by which the glue line could be heated directly. Electrical means appeared most feasible, and a number of experiments were carried out using the glue line as a resistor. Synthetic resin glues in aqueous dispersion show a low conductivity which decreases to nil as the glue dries. The addition of inorganic salts to increase ionic conductivity is of little assistance in this regard. The incorporation of finely powdered metallic conductors showed that conduction and heating effects were produced only at such high concentrations as to render the wood to wood bonding action of the glue impossible. Furthermore, metallic inserts expand with heat and contract after the adhesive has set and the source of heat has been removed, thus setting up serious stresses in the glue line. Various carbon blacks including finely divided reinforcing blacks, were incorporated into glue dispersions. It was found, however, that the conductivity attained for a usable concentration of black was low, and the heating effect produced in the glue line was correspondingly low. Graphite yielded results which showed little improvement.

Results then were obtained with acetylene black which were of quite a different order. Acetylene black[2] is manufactured by the controlled combustion of acetylene and shows quite remarkable electrical properties when dispersed in non-conducting materials. This action in rubber is well known[3-9] and the so-called conductive rubber is an article of commerce. The specific reason for the special behavior of acetylene black in comparison with other blacks is not understood. It is quite possible that this is linked with specialized surface properties on each particle which may bring about a sticking and chain formation between the particles. Such chain formations, branched to form a scaffolding structure, would explain the high conductivity of relatively dilute dispersions of acetylene black in a non-conducting medium. Streptococci-like chains would provide a number of paths for electrical conductivity with most of the surface left free for action of medium as desired.

Further evidence for this structure is provided by viscosity considerations. If acetylene black is incorporated into a synthetic resin glue dispersion, the viscosity observed is very great. At a concentration of only 10 parts of black per 100 parts of resin and 70 parts of water, the mixture is a paste which does not pour. The suspension is thixotropic and has a definite yield point. Such behavior must be accompanied by a structure in the suspension[10, 11] which requires a minimum shearing force in order to bring about sufficient disruption to permit flow. This yield value obviously will increase rapidly with concentration of the black in the suspension. The yield point and subsequent high viscosity are both somewhat smaller in organic media than in water, showing some wetting action by the organic medium on the black. In contrast to this highly conductive black, ordinary carbon blacks show not only a very low conductivity in such suspensions but also correspondingly a much lesser viscosity. By special treatment, certain carbon blacks can be rendered more highly conductive, and such materials may be used in this process in place of acetylene black.

In general then, the gluing development described in the present study consists essentially of the use of a synthetic resin adhesive in conjunction with acetylene black or other highly conductive black, the glue line thus being rendered conductive. Electrodes of suitable type are placed at the edges of the glue line and a low voltage current of ordinary characteristics, e.g., direct current or 60 cycle a.c., is passed through the glue line. Rapid heating is obtained directly in the adhesive, and the latter is thus conveniently and efficiently hardened. The various factors involved are discussed individually in the following sections.

Forms of incorporation of the black

Glue-black dispersion.—Earlier experiments in this development were carried out with a suspension of the black in a synthetic resin dispersion. The resin was made up according to manufacturer's instructions, and the black was incorporated by agitation with a high-speed stirrer for about 5 minutes.

TABLE I.—CONDUCTIVITY OF BRUSH-COATED CONDUCTIVE GLUE

Series I Brushed perpendicular to direction of current flow		*Series II* Brushed parallel to direction of current flow	
Sample no.	*Current*	*Sample no.*	*Current*
	amp.		*amp.*
1	0.18	7	0.39
2	0.23	8	0.40
3	0.12	9	0.21
4	0.28	10	0.45
5	0.16	11	0.23
6	0.31	12	0.51

* Presented in brief at the Fall Meeting of the Society of the Plastics Industry in New York on November 8, 1943.

† Division of Chemistry, National Research Council, Canada.

1 W. Godfrey and P. H. Bilhuber, MODERN PLASTICS *21*, 89–93, 154, 156 (Sept. 1943).

2 Manufactured by Shawinigan Chemicals Ltd., Canada.

3 E. H. Elden, Rubber Age *47*, 308, 316 (1940).

4 J. Habgood and J. R. S. Waring, Trans. Inst. Rubber Ind. *17*, 50–64 (1941).

5 A. E. June, India Rubber World *103*, No. 5, 47–50 (1941).

6 F. L. Yerzley, Rubber Age *52*, No. 2, 133–134 (1942).

7 L. H. Cohan and J. F. Mackey, Ind. Eng. Chem. *35*, 806–808 (1943).

8 A. R. Kemp and D. B. Hermann, Proc. Rubber Tech. Conf., 893–911 (1938).

9 A. R. Kemp and D. B. Hermann, Rubber Chem. Tech. *12*, 317 (1939).

10 W. Gallay and I. E. Puddington, Can. J. Research *B21*, 171–178 (1943).

11 W. Gallay and I. E. Puddington, Can. J. Research *B22*, forthcoming publication (1943).

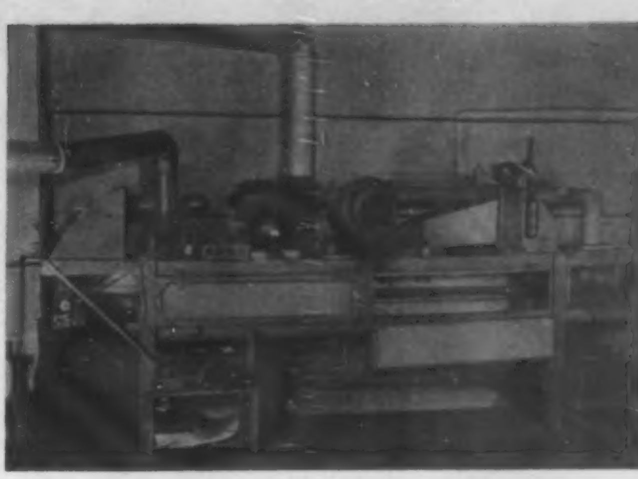
The resultant dispersions formed thick pastes. These thick pastes showed not only a high viscosity and thixotropy, but also an appreciable length of texture, i.e., strings could be drawn from the concentrated paste by touching the surface and lifting. Spreading such a mixture by means of a glue spreader is difficult of accomplishment therefore. It is not considered impossible, and further experiments are now being carried out. However the apparent difficulties led to the use of other forms of incorporation of the black as described in later sections.

Aside from the actual difficulty in spreading, the question of uniformity of spread is of primary importance. In the spreading of normal glue dispersions, uniformity of spread is of no particular consequence so long as reasonable maxima and minima are maintained. The conductivity and hence the rate of heating of the glue-black mixture, however, depends on the concentration of the black. The glue line in this process may be considered as an infinite number of resistors in parallel. It is obvious that any appreciable degree of nonuniformity of spread of the black will result in areas which will be heated slowly when the potential is applied.

The application of the glue-black dispersion to wood by brushing was tried in a large number of experiments. The uniformity of spread was checked both by weight measurements and by conductivity determinations over a given area. The following experiments illustrate results obtained. Several $^3/_4$-in. birch boards, 6 ft. long and 11 in. wide, were coated with weighed quantities of a conductive glue mix to give a spread of 40 lb. per 1000 square feet. Some care was taken to maintain a uniform brushing technique. The boards, after drying, were cut to 1 ft. lengths, and the conductivity measured on passing a 110 volt a.c. potential across 10 in. of the coated surface over a 1 ft. length of surface. In one series the final brush strokes were parallel to the electrodes later applied. In the second series the final brush strokes were perpendicular to the electrodes, i.e., parallel to the direction of flow of the current. Table I shows the results obtained.

The extensive variation in conductivity is noted in each series. This variation would probably be appreciably reduced in actual gluing under the influence of pressure, as later described, but some variation is still to be expected. The great difference between the two series is also of particular interest. It is apparent that the final brushing orients the particles of black so as to form paths favored in that direction. If the final brushing is in the direction of later current flow, the conductivity is very much greater. It was found that with practice an operator became more skilled in the art of more uniform spread by brushing, but the application of this method under industrial conditions cannot be recommended. Similar results were obtained by spraying the conductive glue.

Carriers for the black.—In view of the results described above it was considered desirable to spread a given quantity of the conductive black over a given area as uniformly as possible, and the use of a pre-coated carrier appeared promising. Mesh fabrics show particularly effective properties in this regard since the fabric itself can be coated leaving free areas through which the resin glue, coated on the wood, can readily form a wood to wood bond. Various materials of this type were tried and found effective. The fabric obviously should be as light in weight as possible, consistent with only sufficient strength to withstand the light stresses applied in coating and drying. Mesh sizes should be of the order of 10 to 15 per inch. The fabric should be resistant to distortion when rubbed in the direction of its length. The ease of distortion in the direction of width is of little importance, and thus a leno weave is satisfactory.



1—Pilot scale apparatus for the resin impregnation of fabric, under conditions that are strictly controlled

The impregnation equipment used for this purpose in the laboratory was of a pilot plant scale (Fig. 1). The fabric, 12 in. wide, was fed by guide rolls into an impregnation bath containing the black dispersion. The concentration and level of the dispersion were maintained constant by feed from a reservoir through a circulating pump. After leaving the tank the fabric was fed through adjustable squeeze rolls, the excess feeding back to the impregnation tank. A special device was employed also to free the meshes from deposited material by a current of compressed air. The fabric then was passed through a drier, about 10 ft. in length, at the rate of about $2^1/_2$ ft. per minute. Drying was accomplished by counter-current hot air, under carefully controlled conditions, using an automatic steam valve in conjunction with the heat exchanger. The drying temperature was 60° C. The dried fabric was picked up by tension rolls, synchronized with the squeeze rolls at the wet end.

A certain quantity of resin binder must be used in conjunction with the black in order to hold the coating firmly on the threads. The system proposed for commercial practice is a suspension of the black in an aqueous dispersion of a thermosetting resin. In our laboratory development, however, no tenter system was available, and the use of aqueous dispersions was found to result in excessive shrinkage of the fabric. For our laboratory production runs, therefore, we used a dispersion of the black in a methyl alcohol solution of plasticized polyvinyl butyral. In order to avoid difficulties with very high viscosities in this pilot scale activity, the impregnation mixture consisted of 3 parts of acetylene black, 3 parts of plasticized polyvinyl butyral and 100 parts of methyl alcohol. In order to attain a sufficient concentration of the black on the fabric, the fabric was recirculated six times through this mixture and the drier. About 50 ft. of fabric thus was treated as a batch. It should be emphasized that this treatment probably can be greatly simplified on a large scale. The coating thus obtained showed excellent uniformity not only on a weight basis but also from the point of view of conductivity at various positions. Successive batches were also shown to be satisfactorily uniform.

The method of use of this conductive mesh fabric is very simple. The resin adhesive which is to be used is spread as usual on the wood surface, and double application is preferred. The conductive fabric is placed in the glue line,

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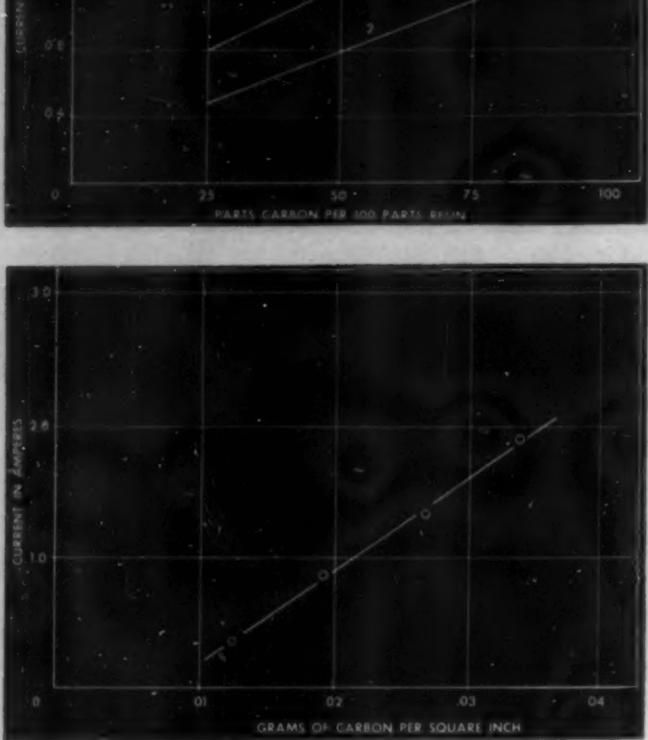

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2—Relation between concentration of conductive black (resin-black dispersion method), and conductivity: 1, aqueous dispersion; 2, toluene dispersion. 3—Relation between concentration of conductive black (fabric mesh carrier method), and conductivity in the glue line

the electrodes are put in position and the assembly is placed under pressure. On application of the potential the black is heated, and this heat is conveyed over the very short distances to all of the glue which sets rapidly. The light fabric does not result in any appreciable thickening of the glue line, and the quality of the glue line is very good as shown below.

Various experiments were also tried in attempts to use paper as a carrier.[11] Various proportions of acetylene black were incorporated into a kraft pulp stock on a laboratory scale, and the resultant paper sheeted out. The use of this conductive material in actual gluing experiments as described above, resulted in rapid setting of the glue and excellent adherence of the carrier to the wood. It was apparent, however, that there was little penetration of the glue through the carrier, and the conductive paper behaved essentially as an extra ply. The glue line was found to have low shear strength, failure occurring within the paper carrier.

Carriers for black and resin glue.—Film glues offer the great advantage of complete fabrication so that the operations of mixing and spreading glue are obviated. The development of fabric mesh carriers for the conductive black obviously can be extended to form a pre-fabricated film glue. For this purpose it is not feasible to coat the fabric with black and resin glue simultaneously since the resin film should be continuous and the black should be confined to a coating on the threads only in order to preserve strict uniformity in conductivity. The two operations must therefore be successive. The mesh fabric is coated with black as described in the preceding section. This conductive mesh fabric is then impregnated from a resin adhesive dispersion so as to form a continuous film of resin over the whole area of the fabric. It is preferable to arrange this in such a manner that the coating is somewhat greater on one side than on the other, thus disturbing as little as possible the contact between electrode and conductive carbon. Some plasticization and flexibility in the resin film is desirable for handling purposes, so that pieces of film will not break out of the meshes on bending or through mechanical stresses. Such film glues were evaluated in gluing trials. The film was placed between the wood surfaces to be bonded, the electrodes were placed in position and the assembly subjected to pressure. Application of a potential resulted in rapid heating and setting of the glue. The quality of the glue line thus formed was excellent.

Similar experiments were also conducted in an attempt to use paper as carrier for both black and resin glue.[12] Acetylene black was incorporated into a kraft pulp stock in an aqueous dispersion of a resin adhesive. The resultant paper was tried out in gluing. It was found, however, that the glue line was very low in strength, and failure occurred readily within the paper. It was found that paper with incorporated black could not be subsequently impregnated with resin glue owing to great difficulty in wetting the black.

Unsupported resin-black films.—Certain types of thermosetting resins can be plasticized to yield a flexible film. Experiments were undertaken therefore in attempts to produce a resin adhesive film having incorporated in it a sufficient quantity of black to show adequate conductive properties. The effect of the black in such mixtures is particularly important in the decreased strength and toughness of such films, and certain difficulties in the technique of such manufacture have been encountered. Experimentation on this phase of the subject is still under way.

Resin glues used

A great variety of resin glues from various manufacturers have been used in this process. These have included phenol-formaldehyde, urea-formaldehyde, melamine formaldehyde and various mixtures of these resins. Both cold-setting and hot-setting resins have been applied. Cold-setting resins were, in general, heated to a temperature of about 225° F. for rapid cure. Hot-setting resins were, in general, heated to slightly above that recommended in the manufacturer's instructions in order to decrease the setting item. It should be emphasized that the process here described is applicable to any resin glue since a method of application is involved rather than a different gluing action.

Current characteristics

The current used is that directly obtainable in ordinary lighting and power circuits, either d.c. or 60 cycle a.c. The voltage used obviously will depend on the width of the glue line, i.e., the dimension in the direction of current flow. In general, laminated wood is not used in widths greater than 18 in. and 220 volts is sufficient for this dimension. One hundred and ten volts have been found to be ample for widths ranging up to 6 in. and may be satisfactorily used up to about 12 inchs. It is apparent that the use of higher voltage will increase the power input accordingly and consequently

[11] The cooperation of the Pulp and Paper Research Institute, Canada, is gratefully acknowledged.

decrease the time necessary to reach a given temperature in the glue line. Such relationships are discussed further in a later section. For any purpose involving much greater widths, it is apparent that the distance may be effectively reduced and the necessary potential lowered, by the addition of a third electrode half-way across the glue line acting as the ground for the outside electrodes.

The current drawn in the process for a given voltage, will vary directly as the total area of glue line. This will vary not only with the voltage but also with the concentration of conductive black per unit area. A typical example might be about 12 amp. per 1000 sq. in. at 220 volts, using fabric mesh carrier. Glue lines are all attached in parallel, and the total current consumption therefore is additive. Here again the uniformity in resistivity in the different glue lines must obviously be good in order to avoid differentials in temperature from one glue line to another.

Proportion of conductive black

It is apparent that a relation exists between the amount of black used per unit area of glue line and the heating effect subsequently produced. At very low concentrations of black, few paths will form, and the conductivity will be too low. At very high concentrations, gluing will be seriously interfered with since too large a fraction of the area will be unavailable for wood to wood gluing by the resin. Between these limits there is a very broad range of useful concentrations.

The effect of concentration of black is illustrated in the following examples:

a). The amount of black noted was dispersed in the phenolic resin solution by mixing for 5 min. with a high speed stirrer. The mix was then brushed onto birch veneers using a spread of 35 lb./1000 square feet. A standard technique was used. The weights of the coated veneers were determined before and afterward, and the necessary corrections assumed. Current was measured over a 5 in. throw using standard contacts. Figure 2 shows the results obtained for 110 volts; curve 1 is for water dispersions and curve 2 for toluene dispersions. Within these limits there appeared to be a linear relation between concentration of black and conductivity. Twenty-five parts of acetylene black was found to yield satisfactory results with 100 parts of any resin adhesive, and this proportion was adopted as a general standard.

b). In this case the conductive fabric mesh carrier was used in conjunction with synthetic resins. The glue line was put under a pressure of 250 p.s.i., and the conductivity read for a 10 in. throw over a 1 ft. length under a potential of 110 volts. Figure 3 shows the results obtained in averages of several experiments. It is noted again that there is a straight line function between concentration of black and conductivity. It was found in general that a concentration of 0.03 to 0.04 gm. of black per sq. in. of fabric yielded satisfactory results.

Dimensions of assembly

The process is essentially independent of the dimensions of the assembly being glued. The time necessary to reach a given temperature in the glue line is independent of the length of the assembly, the thickness of each layer and of the number of glue lines being heated in parallel. These dimensions affect merely the amount of current which will be drawn by the circuit. The time of gluing is also essentially independent of the width of the assembly so long as the potential used is increased with wider assemblies. The method lends itself well particularly to large scale work.

Time of gluing

The time necessary to bring the glue line up to the required temperature obviously may be varied almost at will. Using a high voltage, the power input may be made so large that the whole operation is completed in a matter of several seconds. Generally there is no reason for any excessive speed and, using voltages from 110–220 with a normal concentration of black as noted above, the time under pressure may range from about 2 to 15 min. depending on conditions.

Figure 4 shows two time-temperature relations which comprise compilations of data taken from a number of different experiments. The averages obtained showed a strong bend toward linearity. The experiments involved were carried out on $^3/_4$ in. birch, 7 laminations, using fabric mesh conductive carrier. It is apparent that the relation between curves *A* and *B* should be proportional to the power input—in this case 4 : 1. The time of gluing has, however, an appreciable effect in that (*Please turn to page 168*)

4—General time-temperature heating curves at two voltages (fabric mesh carrier methods) showing rapidity of heat application to the glue line. 5—Relation between energy input and temperature in the glue line for two voltages: 1,220 volts and 2,110 volt,

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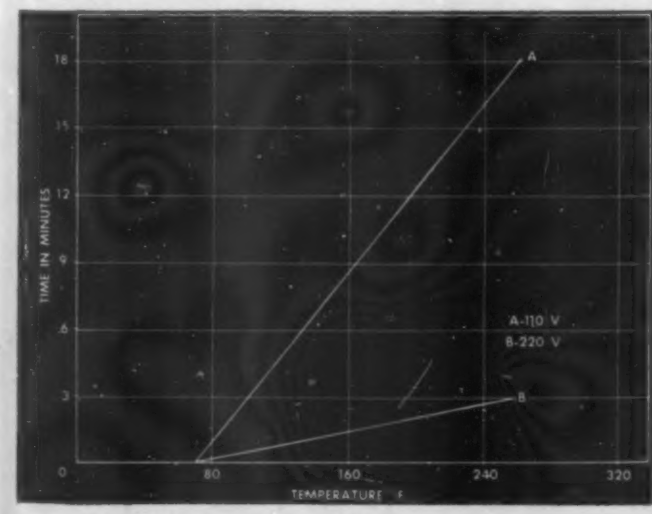

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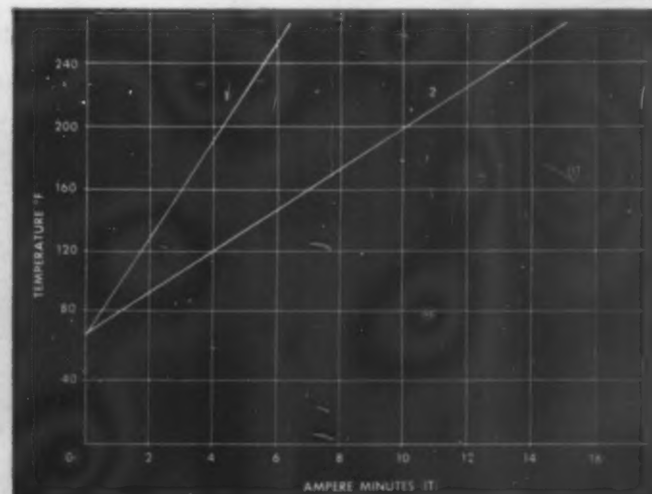
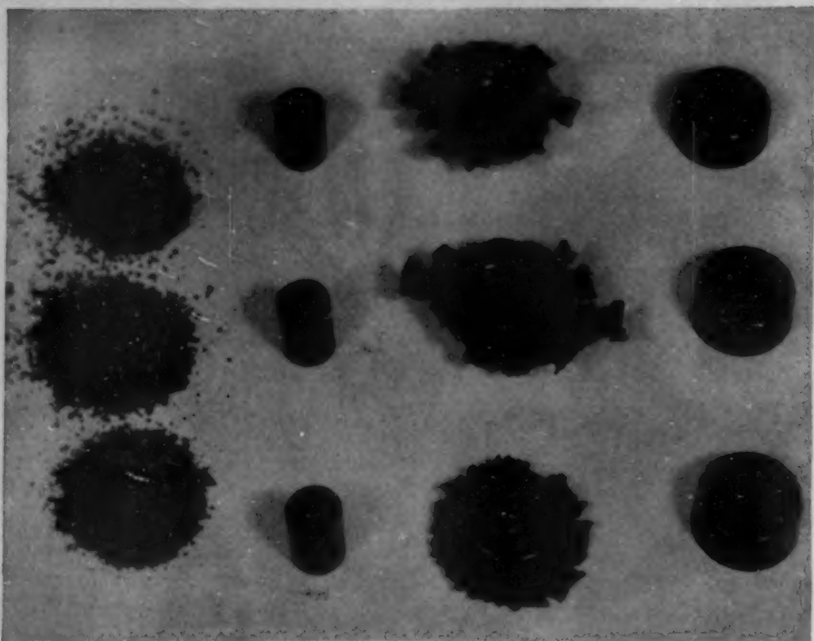


Life On The

BEETLE "STRIPPING" MATERIAL SPEEDS MASS PRODUCTION ON SMALL PARTS



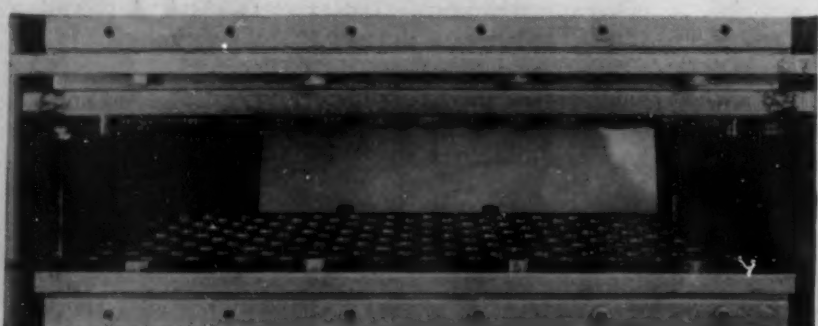
(Above, Left to Right) **BEETLE** molding compound in powder form, preform pills, caps with flash adhering, completed Anchor Molded Caps.

Development of a new "stripping" grade of BEETLE*, designed primarily to aid in speeding the mass production of molded caps and closures, makes available for the first time a urea-formaldehyde molding material that also has sufficient temporary elasticity to permit ejection of the molded pieces from the threaded male die or force plug without unscrewing.

Thus, to the other advantages of BEETLE—chemical inertness, light weight, durability, availability of a wide range of colors—is added the "stripping" advantage which contributes materially to the production efficiency of modern molding techniques.

Pictured here are steps in the manufacture of molded plastic caps at the Anchor Hocking Glass Corporation in Lancaster, Ohio. BEETLE, first preformed, is molded in multi-cavity steel dies, the caps ejected, then tumbled to remove flash. The last step is the lining operation, and afterward the caps are given final inspection and are ready for packing and shipping.

Further information on BEETLE and other Cyanamid plastics for applications in both molded and laminated products where their good physical and electrical properties are necessary is available on request.



(Above) **MOLDING CYCLE COMPLETED** except for ejection shows the caps adhering fast to the force plugs.

(Above) **CAPS ARE STRIPPED** from force plugs into a tray and are then transferred from the tray into the tumbler.

(Above) **FLASH KNOCKED OFF** caps by rotation of tumbler drops through screen into tray.

Extrusion of ethyl cellulose plastic*

Ethyl cellulose, Type ELT, is flexible and has a high-impact resistance at temperatures far below zero

PLASTIC compounds based on ethyl cellulose and marketed under the trade name of Ethocel[1] plastic have created increased interest in extrusion methods of fabrication during the past few years. The outstanding properties of ethyl cellulose plastic have recommended its use in many applications. New formulations have been introduced which have increased the use of ethyl cellulose in military applications where rigid specifications have been met. Many items formerly made of metals now are being produced from this versatile plastic with excellent performance records in actual use.

Ethyl cellulose is one of the easiest plastics to extrude and extruded sections can be made rapidly and successfully within specified limits. Ethyl cellulose is stable to heat, and standard plastic extrusion equipment handles it very satisfactorily. The extrusion Ethocel as well as the material for compression and injection is produced in grades ranging from a soft, flexible plastic to a hard, rigid material. Two types are supplied regularly for extrusion work. The regular type is designated as ER and the low temperature type is designated as ELT. Type ER is normally used for most applications while type ELT is of exceptional value where extremely low temperatures are encountered. Type ELT also has somewhat better heat resistance than the ER type of material.

Extruded tubing, strips and complicated shapes are very durable owing to the inherent mechanical strength and toughness of the plastic. While ethyl cellulose extrusions normally have a smooth, glossy surface, it is possible to get matte finishes and retain good mechanical properties.

Drying of plastic granules

Ethyl cellulose plastic should be dried prior to extrusion since the absorption of even a small amount of moisture in storage or in transit is apt to result in a poor extruded section. The presence of moisture is often characterized in the extrusion by a rough surface or by blisters. It is recommended that the moisture content for extrusion be kept below 0.01 percent in order to produce extruded sections of the highest quality. Drying the plastic in a hot-air or infra-red oven at 80 to 90° C. for one hour immediately before extruding is ample for all grades of the plastic. The granules should not be placed on the tray deeper than $1^1/_2$ inch.

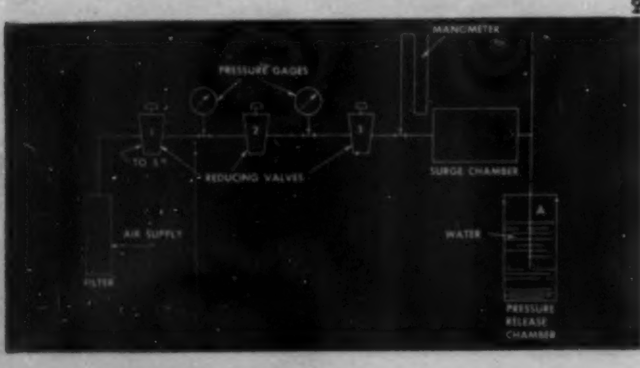
Extrusion temperatures

Temperature control during extrusion is of the utmost importance. Gloss, surface appearance and stiffness of the plastic as it comes from the die are all sensitive to the tem-

* Plastics Division, Dow Chemical Co.
[1] Trade name of Dow Chemical Co.

2—Schematic piping arrangement for air supply in extruding tubing. 3—Uniform tee section extrusion die

2



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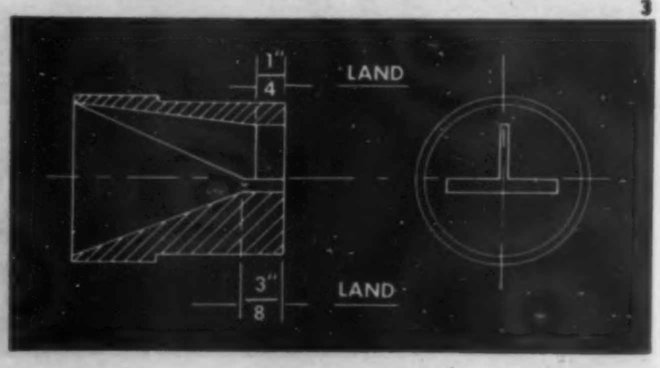

perature of the plastic leaving the die. Therefore with most types of ethyl cellulose plastic, it is best to determine the proper heat for each extruded section before production is started. There are two ways of getting this information:

1. Through technical service supplied by the manufacturer of the plastic.
2. Through close study and control over initial runs.

The temperature of the plastic mass as it comes from the die should be in the range of 340–400° F. Exact temperatures will be determined by the flow grade being extruded. In general, the harder flow grades will extrude best at higher temperatures. Type ELT may be extruded in the same temperature range as that used with the regular type. Where high gloss on the finished piece is desired, the temperature may have to be raised a few degrees particularly at the die face or die holder. Type ELT cannot be extruded with as high a gloss finish as the ER type of plastic.

If the temperature of the extrusion machine is too high for a particular grade of ethyl cellulose plastic, a lustrous but rough and smeared surface will result. High temperature also will cause difficulty in holding form. If too low a temperature is used, a dull "file-like," striated surface will be produced, and in tubing a weak weld will result. The physical properties of extruded sections are affected to a much lesser extent than the surface appearance when the extrusion temperature is not in the recommended working range. Fortunately, temperatures sufficiently high or low to be detrimental to tensile strength, elongation and fatigue are obvious from the appearance of the plastic as it comes from the die. It may be too soft to handle, or stiff and non-uniform. It may even contain lumps of unsoftened material. All of these characteristics may be recognized by the operator during the extrusion.

It is suggested that the plastic extrusion machine have at least three, and preferably four, individually controlled temperature zones. To facilitate feeding, the first section should be kept cool. The second zone is for preheating the material so that it will adhere to the cylinder walls and slip on the screw for optimum rate and uniformity. The third zone is maintained at a higher temperature for heating to proper extrusion temperature and plastification. The fourth zone, consisting of the die or die holder, should have a separate temperature control. An electrically heated die, controlled by a rheostat with an indicating pyrometer, is very satisfactory. This method of heat control also is of value since it increases the ease of extruding complicated cross sections by lessening the cooling problem as the surface may be highly heated for finish with a cool mass for stiffness of the section. At the same time there is less chance of obtaining poor physical properties in such a section. This method is also of particular value in the extrusion of tubing since the plastic mass may be maintained at optimum temperature for producing strong welds and a desirable surface finish may be obtained as previously pointed out.

Take-off procedure

The extruded plastic may be taken from the machine either by conveyor or by draw rolls. A conveyor with a metal belt appears to be superior to a rubber belt as it increases the rate of cooling, minimizes belt marks on the surface and gives a more uniform rate of take-off. Water may be employed as a cooling medium although, in general, this has not proved to be as satisfactory as air cooling. Most likely, experience is the best means of determining whether ethyl cellulose plastic should be extruded directly into a cooling bath through water sprays or onto a conveyor. Air jets may be employed as a cooling blast on the conveyor.

Draw rolls, used directly after a water bath or at the end of a conveyor, give very good results. These rolls are particularly adapted for use on flat sections, strips and tubing. They insure a uniform rate of take-away from the die and eliminate the possibility of occasional belt or section slippage which is detrimental to uniform section production and tolerances. Draw rolls also are valuable when the extruded section is fed directly into an automatic cut-off device or wind-up equipment.

Form molding devices, or cold forms as they are more commonly called by the trade, and shaping rolls also are used as a part of the take-off. In fact, with many plastic sections, these items are important. The shape of the cold

4—Plastic strip die. 5—Die and mandrel assembly for plastic tubing. 6—Non-uniform tee section extrusion die

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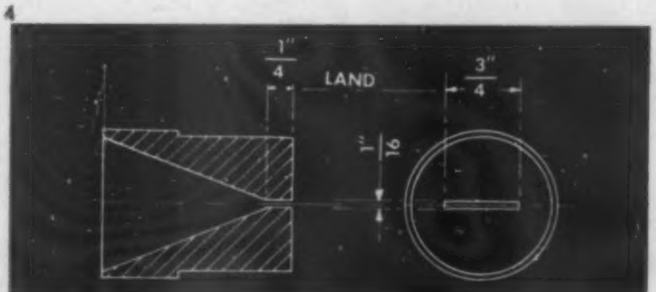

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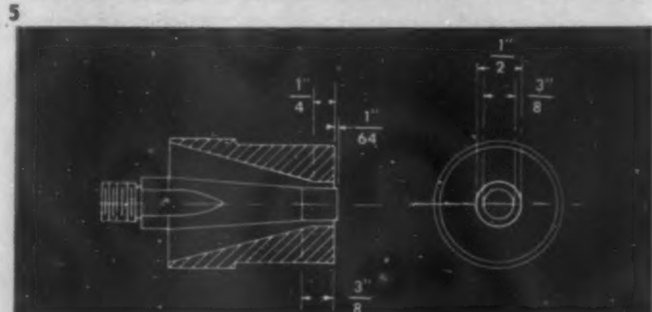

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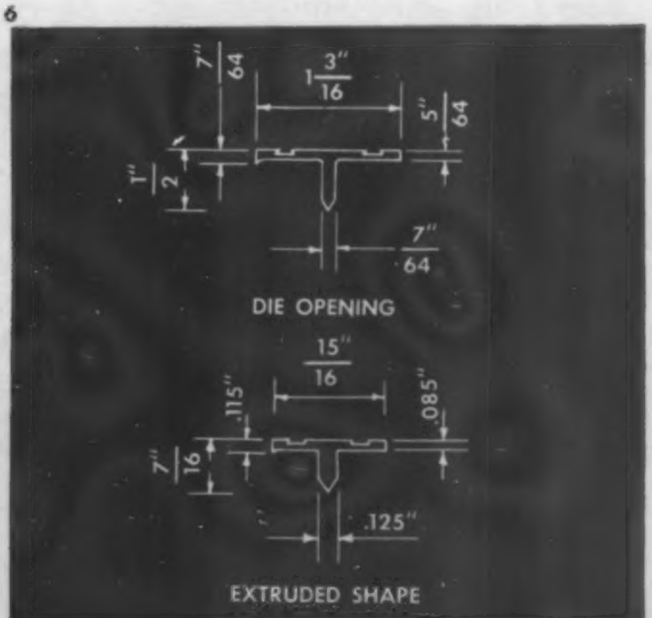
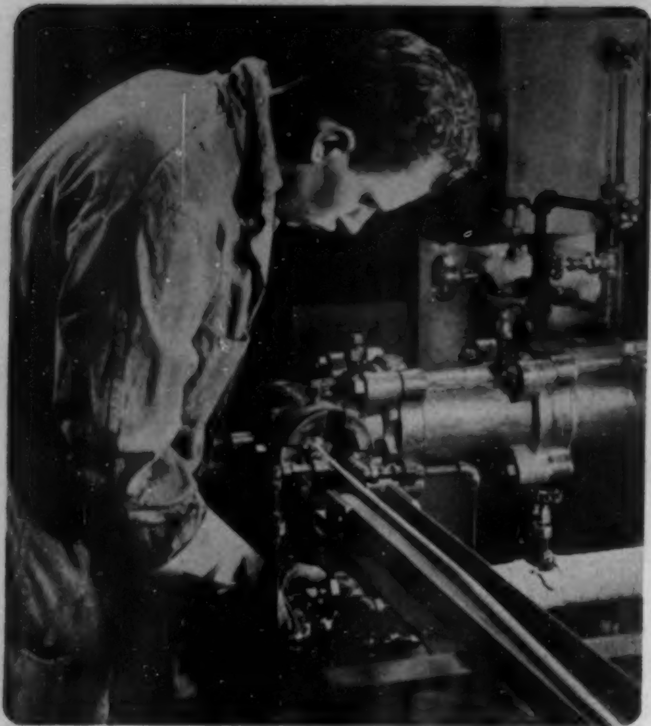




7—Ethyl cellulose tubing, Type ER, is extruded in standard plastic equipment such as that shown above

forms should be designed to conform to the contour of the extruded section. Usually they are water-cooled, and the plastic is drawn over or through them. The tolerance which the extruded section must meet will play an important part in deciding equipment necessary at the take-off.

Production of tubing

The extrusion of ethyl cellulose tubing presents somewhat of a different problem from that of shapes. This is due to the fact that air generally is required to inflate the tubing during the cooling period. To produce satisfactory tubing, it is advisable to have a uniform and constant pressure source which can be controlled to a maximum of 0.1 p.s.i. of water pressure variation, preferably less. It is also advisable to employ a relief mechanism which will prevent the air pressure from fluctuating during production.

Figure 2 shows a typical arrangement of valves for controlling air pressure. Three reducing valves are used in series to minimize any surging caused by fluctuation in line pressure. The pressure delivered to the plastic tubing is controlled by adjusting the depth of control tube *A* in the water pressure release chamber. The control tube should be regulated to deliver the pressure desired for a particular size tubing. The reducing valve then should be adjusted to a point where air bubbles slowly come from the bottom of the tube *A*. Constant air pressure is extremely important to insure uniform-size finished tubing.

Two methods of using air to inflate tubing are in practice. In one method the tubing is always open, allowing the air to escape continuously. In the other method the tubing is sealed, and no air is allowed to escape except through the pressure relief mechanism.

A practical set-up for the extrusion of ethyl cellulose tubing is as follows: The conveyor is set 8 to 15 in. from the die and may range in length from 15 to 30 feet. At the end away from the extrusion machine, draw rolls are located to take the cooled tubing and feed it to the cutter or wind-up device. The rolls and conveyor must be synchronized to the same speed. The space between the rolls must be regulated so that the tubing is gripped firmly but not flattened. Both rolls should be driven to obtain the most satisfactory results.

Tolerances for extruded ethyl cellulose

Ethyl cellulose can be extruded to very close tolerances —the variation being of the order of ±1 percent. This variation may be due to numerous causes depending on the section. One cause of variation is the failure of the extruder to produce at a constant rate. In case of variation of section size, uniformity of belt or roll travel in the take-off unit should be very carefully checked. Conveyors, especially, are likely to have a non-uniform motion of the belt which, of course, will reflect back to the die face where the material is very soft and is readily deformed. Operating at too low a temperature may cause surging at the die. Operating with a die having a large opening will at times cause a surging. This may be overcome by the use of an orifice or screen ahead of the die. This restraint will create greater back pressure in the head, and more uniform heating and flow of the material will result. In tubing any minute air pressure variation will cause noticeable size variation as the extruded material at the die face is easily distorted.

Die design

Extrusion dies for ethyl cellulose plastic require a minimum amount of design. Tool steel and stainless steel are very satisfactory for these dies although other metals can be used. The die should be 10 to 25 percent larger than the plastic section to be extruded. Then, by controlling the speed of the extuder and of the take-off mechanism, the extruded piece can be drawn to the proper size. In an extrusion of non-uniform cross section the percentage of draw-down may vary from part to part of the extrusion. Thus a more uniform cross section can be obtained, and the appearance of die marks can be reduced. Figure 6 is an example showing the size of the die and the corresponding extruded shape made from this die.

Ordinarily the die is tapered from the opening to a larger area at the point where the plastic enters the die. Normally $^1/_4$ in. of land is sufficient to give a good surface. This may be varied to suit the cross section being extruded so that pulsations may be minimized. The land must be kept well polished whereas the tapered part can be machine-finished although polishing is advantageous. Figure 4 is a sketch of a die used for extruding Ethocel PG tape. Figure 5 illustrates a tubing die assembly for use on an extrusion machine with a cross head. Figure 3 shows a uniform tee-section extrusion die.

All extrusion dies should be as streamlined as possible and designed to give a uniform rate of flow of the plastic over the entire cross-sectional area. When extruding complicated shapes where part of the section may be thin, it is necessary to restrict the flow of plastic to the thicker portion of the die. Uniform flow through all sections of the die opening may be achieved through restriction of desired portions of the die areas, e.g., by increasing the length of the die land in these areas. As a result of this uniform flow through the die, the section tends to flow straight away from the die face thus producing sections free of tendencies to wrinkle or bow.

Properties of ethyl cellulose extruded plastics

Ethyl cellulose plastic for extrusion is available in both regular and low-temperature types and in flow grades ranging from S_5 to H. A wide (*Please turn to page 180*)

TECHNICAL SECTION

DR. GORDON M. KLINE, Technical Editor

Creep properties of molded phenolic plastics*

by DAVID TELFAIR, T. S. CARSWELL and H. K. NASON†

THE work described herein was undertaken primarily to fill a gap in our knowledge of molded phenolic plastics. Practically no published information on the creep of thermosetting materials was available at the inception of this work, about two years ago, although a few papers have appeared since that time. W. N. Findley[1] has obtained some valuable data on the creep of a fabric-filled phenolic plastic for times as great as 8000 hours. H. Perkuhn[2] has measured the creep of paper laminated phenolics at room temperature for times varying between 200 and 500 hours. He also reports data on time-to-rupture for these materials. H. Leaderman[3] discusses creep and inelastic effects of a phenolic plastic under torsion, but presents a relatively small amount of experimental data. E. E. Weibel[4] reports creep tests of limited duration (2 hr. or less) on photoelastic plastics. His data were taken in connection with photoelastic stress-pattern studies where behavior under constant load over an extended period of time was unimportant.

So far as we know, nothing has been published on the creep of thermosetting plastics at elevated temperatures. A few papers have appeared which include a limited amount of data on the effect of temperature on the creep of thermoplastic materials.[5-8] Several publications present data on the creep of thermoplastics at room temperature.[9-11]

Materials

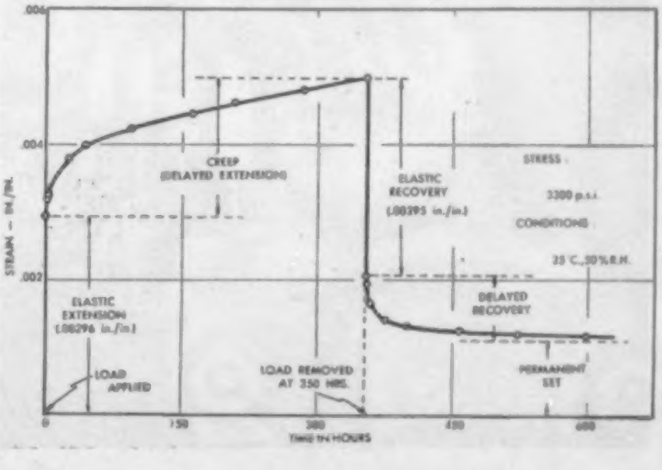
The materials studied included five phenolic compositions containing as fillers woodflour, chopped canvas (rag), cotton cord, asbestos and mica. Data were also obtained for an unfilled phenolic resin. The filled materials contained 50 percent phenol-formaldehyde resin and 50 percent filler with the exception of the asbestos-filled material which contained approximately 40 percent resin and 60 percent filler. This change was necessary to improve molding properties.

The woodflour-filled, asbestos-filled and mica-filled molding compositions were prepared by rolling the resin and filler on a set of differential rolls in the usual manner for the preparation of general purpose phenolic molding compositions. The cotton cord and chopped canvas fillers were blended with the resin in a wet-mix process. The wet resin-filler mix was dried and the resin further polymerized to give a moldable composition. The preparation of a pure resin compound from which clear bubble-free specimens could be molded presented some difficulty, but a method was finally developed which, together with suitable molding technic, gave satisfactory specimens. All materials were compression molded using approximately a 6 min. cure at 170° C., and a pressure on the specimen of 4000 pounds per square inch.

Definitions

When an object is stressed the resulting deformation may, in general, be thought of as consisting of 1) instantaneous elastic deformation plus 2) delayed deformation. The first is independent of time and depends only on the stress and the elastic moduli of the material. This is the elastic strain which is considered in the classical theory of elasticity. The

1—*Strain vs. time curves for a cord-filled phenolic*



* Presented before the Rubber and Plastics Group of American Society of Mechanical Engineers, New York, N. Y., on Dec. 2, 1943.

† Research Department, Plastics Division, Monsanto Chemical Co.

1 W. N. Findley, "Mechanical Tests of Macerated Phenolic Molding Material," N.A.C.A. Report, June 1943 (Restricted).

2 H. Perkuhn, "The Creep of Laminated Synthetic Resin Plastics," Luftfahrtforschung *18*, No. 1 (1941); N.A.C.A. Technical Memorandum No. 995.

3 H. Leaderman, "Creep, Elastic Hysteresis and Damping in Bakelite under Torsion," J. Appl. Mech., p. A-79 (June 1939).

4 E. E. Weibel, "Studies in Photoelastic Stress Determination," Trans. A.S.M.E. *56*, 637 (1934).

5 R. Burns, "Deformation Under Load of Rigid Plastics," A.S.T.M. 1943 Preprint No. 87; MODERN PLASTICS *21*, 111–112 (Sept. 1943).

6 J. Delmonte and W. Dewar, "Factors Influencing Creep and Cold Flow of Plastics," A.S.T.M. Bulletin No. 112, 35 (Oct. 1941); MODERN PLASTICS *19*, 73–79, 110 (Oct. 1941).

7 W. F. Busse, E. T. Lessig, D. L. Loughborough and L. Larrick, "Fatigue of Fabrics," J. Applied Physics *13*, 715 (1942).

8 W. F. Bartoe, "Service Temperature Flow Characteristics of Thermoplastics," MODERN PLASTICS *17*, 47–49 (March 1940).

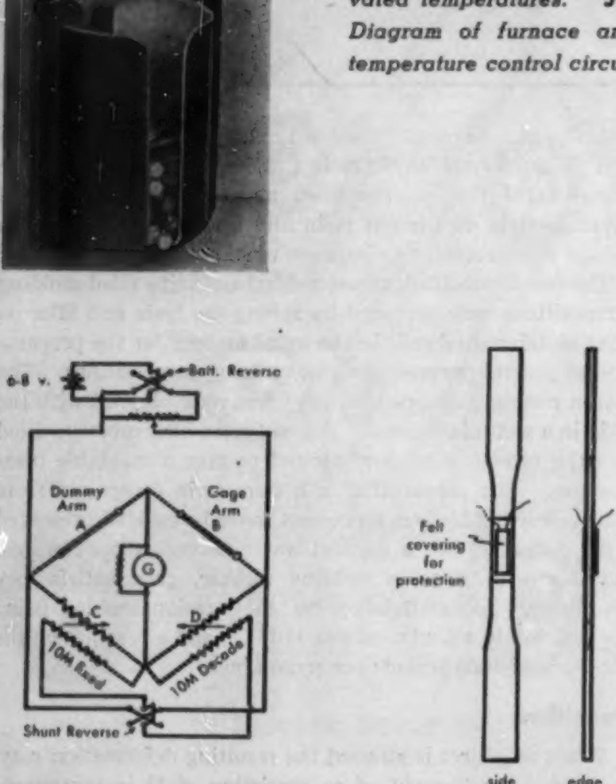
9 C. H. Penning and L. W. A. Meyer, "Cold Flow of Thermoplastic Materials," MODERN PLASTICS *17*, 91–93 (Nov. 1939).

10 W. N. Findley, "Mechanical Tests of Cellulose Acetate," Proc. A.S.T.M. *41*, 1231 (1941); MODERN PLASTICS *19*, 57–62 (Sept. 1941).

11 W. N. Findley, "Creep Tests on Cellulose Acetate," MODERN PLASTICS *19*, 71–73 (Aug. 1942).

2

2—*Specimen, grips and method of loading with lead weights.* 3—*Diagram (a) shows resistance bridge circuit; and (b) method of attaching gage to specimen.* 4—*One of the frames for creep testing at elevated temperatures.* 5—*Diagram of furnace and temperature control circuit*



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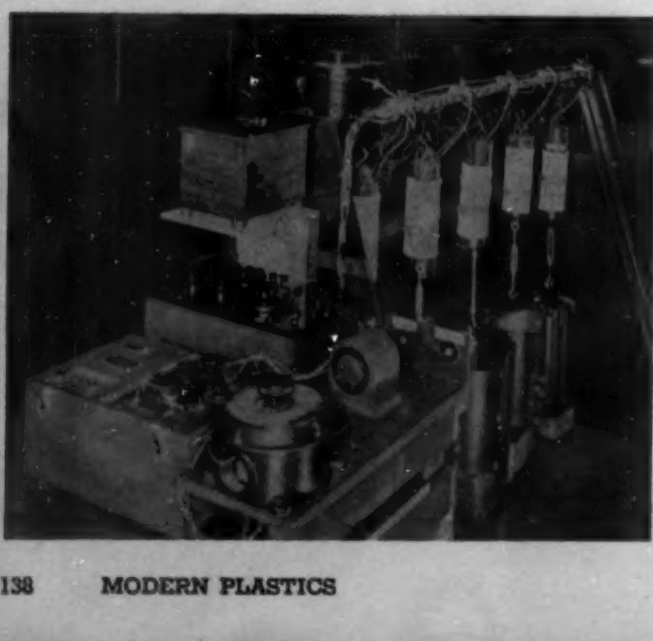

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second, or delayed deformation, depends upon time as well as stress. It may be subdivided into (a) delayed elastic deformation and (b) viscous flow, or non-recoverable deformation.

Most metals, when stressed below their yield point, possess only an insignificant amount of delayed deformation provided the temperature is not too high. Any changes in stresses are followed practically instantaneously by corresponding strains. Consistent with this is the observed fact that metals have a relatively low capacity for damping mechanical vibrations.

Plastics, on the other hand, have a relatively large amount of delayed deformation even for stresses far below their ultimate tensile strengths. As a result, strains lag behind the applied stresses by an appreciable amount, and plastics exhibit a high damping capacity.[12] Figure 1 will serve to illustrate and clarify the meaning of the terms, *elastic deformation, creep or delayed deformation, elastic recovery, delayed recovery* and *permanent set.*

Experimental methods

Because the total deformation for molded phenolic plastics is very small (of the order of magnitude of 0.5 percent), a very sensitive and accurate method of measuring strain must be used. Furthermore, the strain measuring element must be light and require a relatively small force to actuate it. These requirements are fulfilled by an electrical resistance type of gage, based in principle upon the increase in resistance which accompanies the tensile straining of certain metals.[13] Briefly, the gage consists of a fine (1 mil diameter) resistance wire looped back and forth several times and cemented to the specimen. The strain which takes place in the specimen is transmitted to the wire whose resistance increases proportionately. This increase in resistance is measured with an appropriate resistance bridge and used for calculating the strain in the specimen. Strains as small as 5×10^{-5} (or 0.005 percent) may easily be detected by this method. A more detailed description of the construction and operation of these gages may be found in the literature[14-16] or may be obtained from the manufacturers.[17]

For creep testing at both room and elevated temperatures, A.S.T.M. D638 Type 1 tensile specimens were used. Four heavy angle-iron frameworks supported a total of 26 room temperature and 17 elevated temperature specimens. Each

[12] As pointed out by Lazan [Trans. A.S.M.E. *65*, 87–104 (Feb. 1943); Modern Plastics *20*, 83–88, 136–144 (Nov. 1942)] a high damping capacity may, in many structural applications, be a very desirable property.
[13] P. W. Bridgman, "The Effect of Tension on the Thermal and Electrical Conductivity of Metals," Proc. Am. Acad. of Arts and Sci. *59*, 119 (1922).
[14] A. G. H. Dietz, "Stress-Strain Relations in Timber Beams," A.S.T.M. Bulletin No. 118, 19 (Oct. 1942).
[15] A. V. de Forest, C. W. MacGregor and A. R. Anderson, "Rapid Tension Tests Using the Two-load Method," Metals Technology *8* (Dec. 1941).
[16] A. V. de Forest, "Some Complexities of Impact Strength," Metals Technology, *8*, No. 5 (Aug. 1941).
[17] Baldwin Southwark Div., Baldwin Locomotive Works, Philadelphia, Pa., and Ruge and de Forest, Consulting Engineers, 76 Mass. Ave., Cambridge, Mass.

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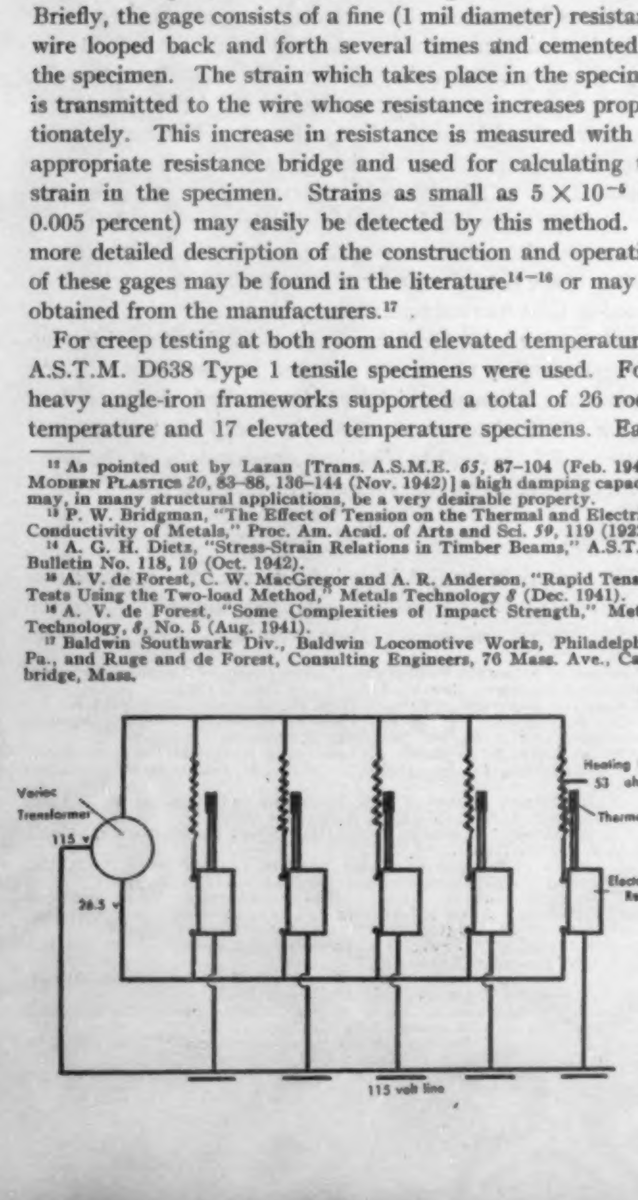

specimen could be loaded to the desired stress by means of buckets and lead weights. Figure 2 is a photograph of a portion of one of the room-temperature frames, showing the method of gripping and loading the specimens. Two gages were attached to each specimen, one to each side of the uniform center section, as shown in Fig. 3a. The two gages then were connected in series to form a single resistance. An unstressed specimen with gages similarly attached, was used in each case for a balancing arm of the resistance bridge (Fig. 3b). This had the effect of automatically minimizing any errors caused by the slight changes of resistance which accompany minor variations in temperature.

A photograph of part of the equipment for work at elevated temperatures is shown in Fig. 4. The system of furnaces, thermostats and relays used is shown schematically in Fig. 5. A cross section of the heating unit can be seen in Fig. 6. Small bimetallic thermostats were used to actuate electronic relays for temperature control. The temperature measuring system consisted of an iron-constantan thermocouple placed near the center of each measuring gage, a thermocouple switch and a Rubicon type B potentiometer. Figure 7 is a schematic wiring diagram of a typical measuring gage circuit, dummy gage circuit and switching arrangements. Shallcross No. 4615 silver contact switches were found to give satisfactory results providing care was exercised in keeping the contact points clean.[18]

The desired loads were applied in the form of lead weights added in convenient increments. Strain readings were taken for each load increment, and the results were used for obtaining modulus data. From 4 to 6 min. were required for loading by this method.

At the higher temperatures, measurements first were made

[18] A. C. Ruge has recently used an adaptation of the Kelvin bridge for successfully minimizing contact resistance errors which frequently arise in switching arrangements.

6—Cross section of furnace. **7**—*Switching arrangement for measuring gage and dummy gage circuits.* **8** *and* **9**—*These two curves show the creep and recovery of wood-flour-filled phenolic (25° C., 50% R. H.)*

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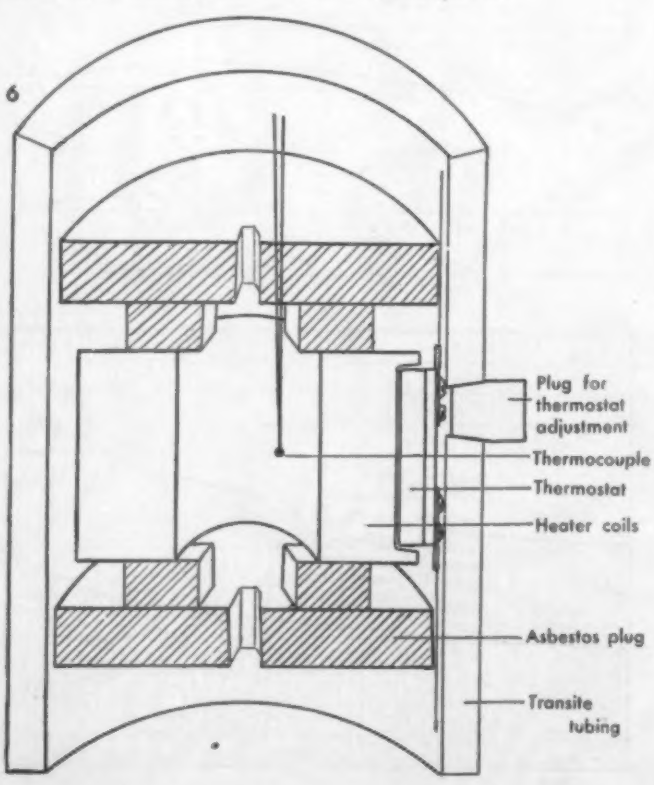

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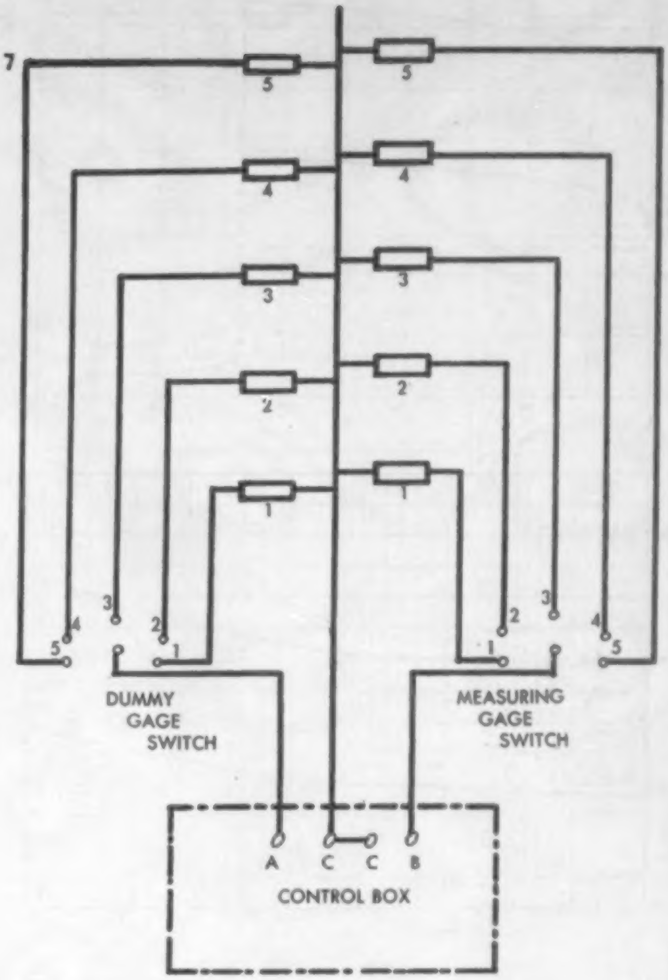

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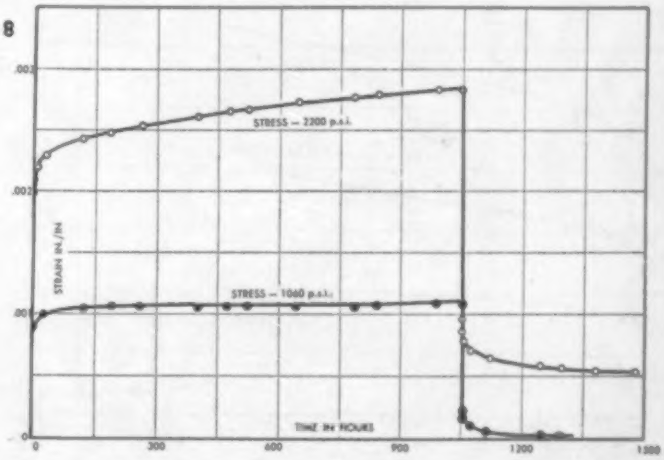

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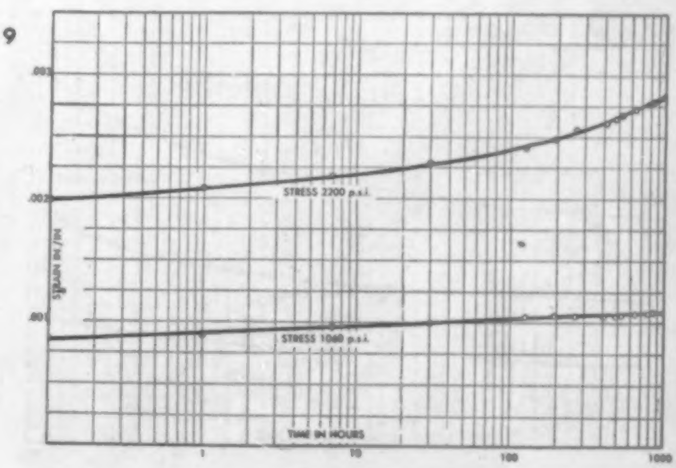

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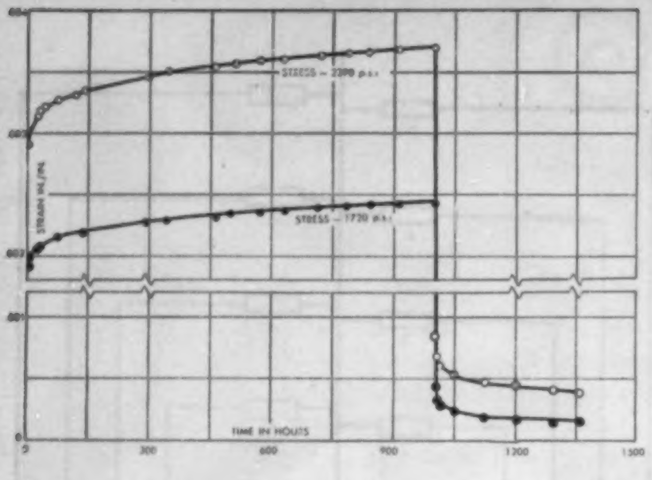

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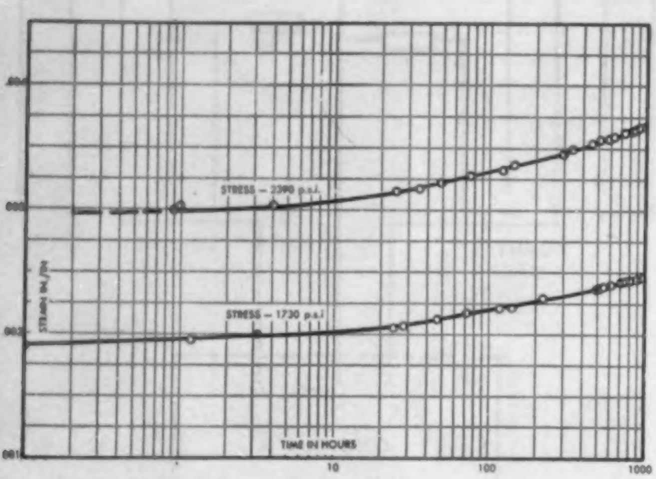

with the dummy gages mounted on the same, or similar material, and both dummy and stressed specimen were kept in the furnace at the same temperature. Later, when a gradual shrinkage of the unstressed or dummy specimen was observed to take place, special standard dummies were prepared by mounting gages on unglazed porcelain. In this way, freedom from shrinkage of the dummy gage was assured.

Early work at elevated temperatures indicated that the standard Type A-1 paper-mounted gages, cemented in the usual way, had a tendency to slip slightly with respect to the specimen. Consequently, a program of experimental work was undertaken in cooperation with A. C. Ruge which resulted in the development of a special heat-resisting gage, with the resistance element cemented directly to the surface of the specimen with a liquid phenolic resin cement. These gages were tested for slip by cementing them directly to a steel bar, giving the bar a permanent set by bending beyond the yield point and checking the gage resistances for constancy while held at 75° C. for one month.[19] No appreciable slip was observed by this method. Since resin-to-plastic bonds are observed to be stronger than resin-to-steel bonds, the above test indicated very little likelihood of slip for this type of gage mounting in actual creep work.

Any attempt to accurately measure minute changes in the state of a system over relatively long periods of time is likely to be filled with difficulties, especially when the work is done at elevated temperature. The work now being described

[19] This method was suggested by W. N. Findley of the University of Illinois.

10 and 11—Creep and recovery of phenolic resin compound (25° C., 50% R. H.). 12 and 13—Creep and recovery of rag-filled phenolic (25° C., 50% R. H.). 14 and 15—Creep and recovery of cord-filled phenolic (25° C., 50% R. H.)

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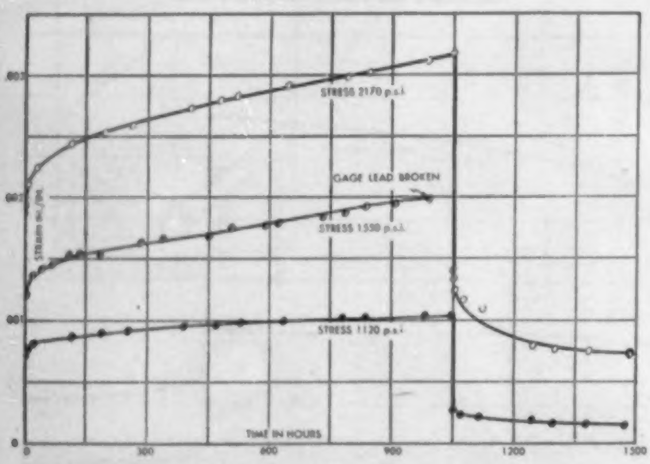

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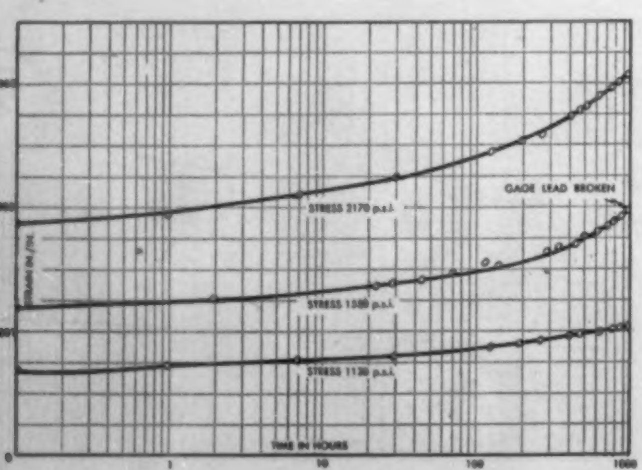

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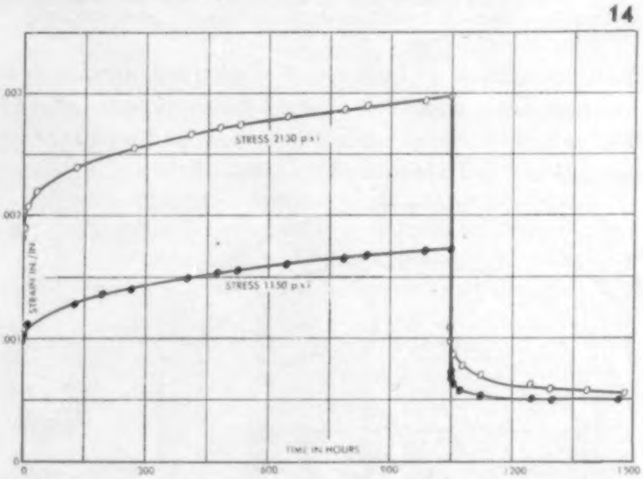

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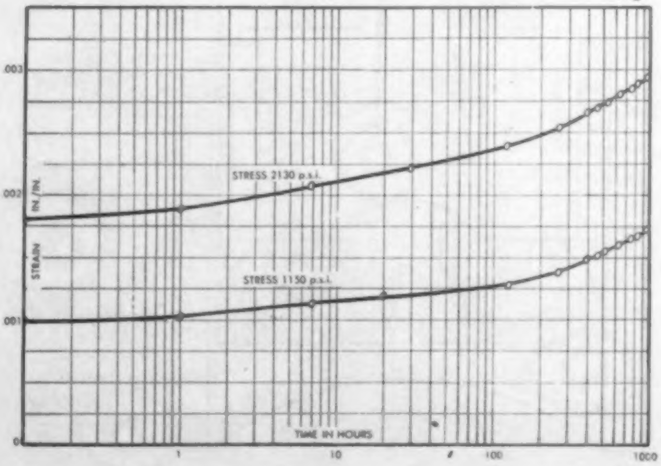

was no exception. Principal difficulties were as follows:

1. Changes in contact resistance of the gage selecting switch and of the bridge binding post connections.

2. Changes in the insulation resistance of the material separating the gage and dummy circuits electrically.

3. At elevated temperatures, failure of the measuring gage to follow completely the strain of the specimen due to slipping of bond between gage and specimen.

Methods of eliminating or controlling these sources of error are discussed in the appendix.

Experimental results

The results of creep measurements at room temperature (25° C.) for the six molded phenolic compositions are shown in Figs. 8 through 19. Data have been plotted using both linear and semi-log coordinates. The latter method makes it possible to compare long-time effects more readily. Figure 20 shows the average total inelastic deformation after 1000 hr. of constant stress, plotted against stress. From these curves, the stress required to produce a total creep of 0.003 in./in. during a 1000 hr. test may be estimated roughly as follows:

Cord filled	500 p.s.i.
Rag filled	900 p.s.i.
Woodflour filled	1100 p.s.i.
Resin compound	1400 p.s.i.
Asbestos filled	1900 p.s.i.
Mica filled	2500 p.s.i.

Qualitatively, all of the materials tested possess the same

***16 and 17**—Creep and recovery of asbestos-filled phenolic (25° C., 50% R. H.). **18 and 19**—Creep and recovery of mica-filled phenolic (25° C., 50% R. H.). **20**—Curves showing total creep after 1000 hr. vs. applied stress*

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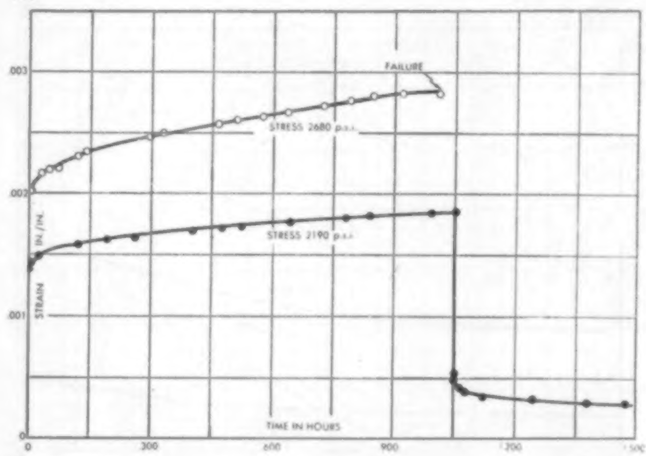

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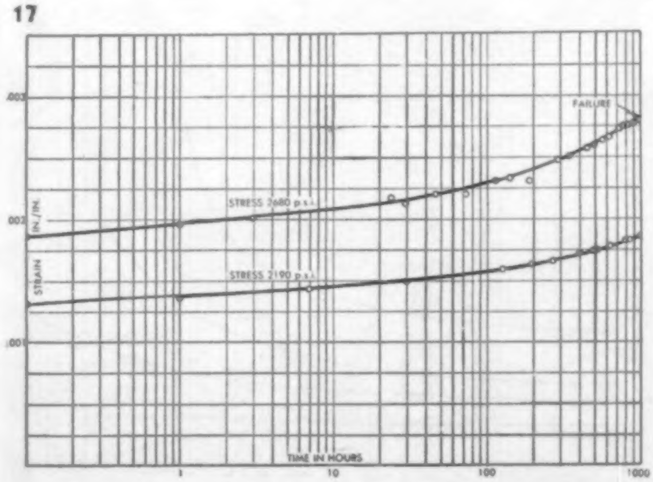

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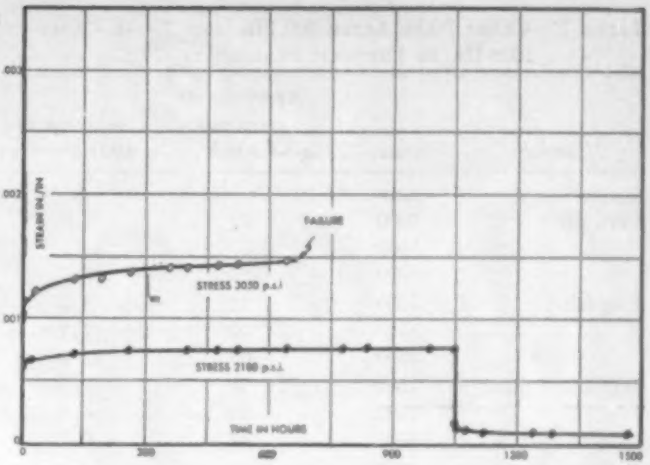

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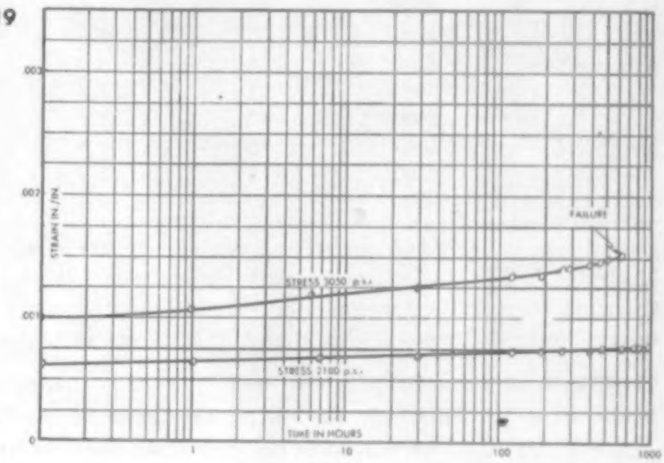

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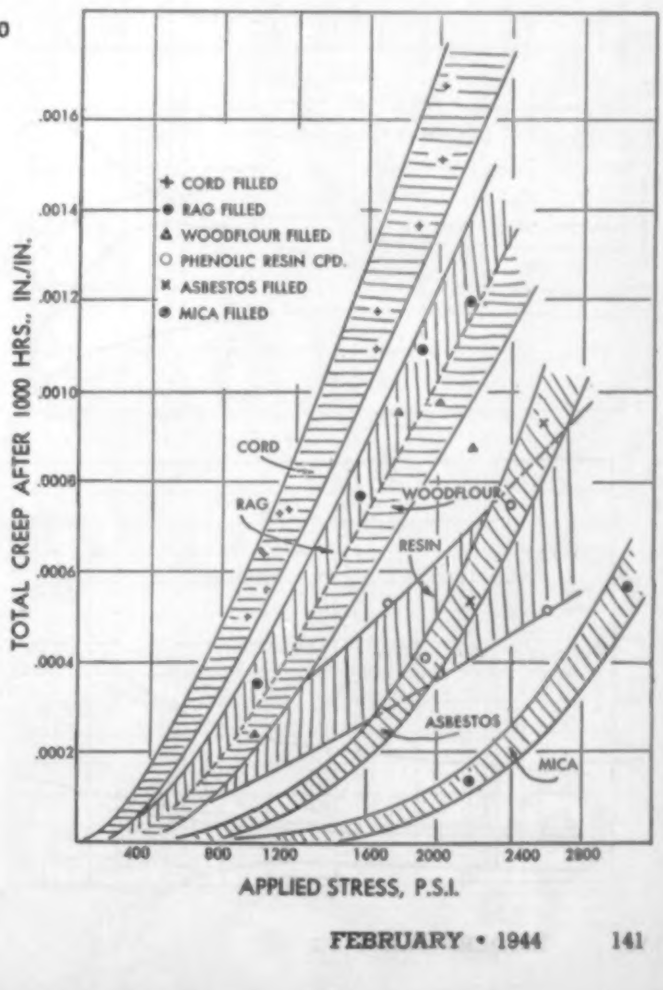

TABLE I.—CREEP RATE AFTER 500 HR. AND TOTAL CREEP IN 1000 HR. OF PHENOLIC PLASTICS AT 77° F.

Material	*Stress*	*Approximate creep rate after 500 hr.*	*Total creep in 1000 hr.*
	p.s.i.	*10^{-8} in./in./hr.*	*10^{-4} in./in.*
Cord filled	1000	32	5.8
	1500	53	10.4
	2000	72	15.3
Rag filled	1000	21	3.5
	1500	40	7.2
	2000	63	11.2
Woodflour filled	1000	10	2.3
	1500	23	6.0
	2000	47	9.3
Resin compound	1000	11	2.3
	1500	19	3.5
	2000	26	4.8
	2500	35	6.5
Asbestos filled	1500	8	2.0
	2000	21	4.3
	2500	45	8.1
Mica filled	2000	3	1.0
	2500	6	2.6
	3000	10	5.4

general type of creep and recovery curves, namely, the type illustrated in Fig. 1. A pseudo-elastic deformation follows the application of the load practically instantaneously, and merges into rapid creep which gradually decreases in rate and eventually appears to approach a constant rate for long times and high stresses. For this reason, the creep rate after 500 hr. of constant load as well as the total creep or total inelastic deformation after 1000 hr. have been listed in Table I. For a number of the specimens, recovery curves were run out to 300 or more hours after unloading. All of the materials tested showed an "instantaneous" elastic recovery which was numerically equal (within a few percent) to the "instantaneous" elastic deformation produced by the original loading. This was followed by a period of "delayed elastic recovery."[20] In most cases it appeared that a considerable permanent set had been produced.

At 160° F., the tendency to creep, as measured by the total inelastic deformation after 1000 hr., is roughly two or three times as great as at room temperature. However, two opposing effects come into play as the temperature is raised. Superimposed upon the increased creep rate is a tendency for the material to shrink, and to become harder and more brittle. On no occasion did any of the materials show what could be called a "ductile" behavior. Figure 21 shows creep curves for four materials at about 160° F. (70° C.). The apparent shrinkage after several hundred hours at the low stresses was at first thought to be erroneous, but later experiments proved adequately that shrinkage was actually present.

As might be expected, at 190° F., creep rates tend to be even higher than at 160° F. Also, the shrinkage effect is much in evidence for low stresses. Figures 22 through 27

[20] R. Houwink, "Elasticity, Plasticity and the Structure of Matter," London: Cambridge Univ. Press (1937).

21—*Creep of phenolic plastics at 70° F.* **22**—*Creep of woodflour-filled phenolic at average temperature of 192.4° F. (89° C.).* **23**—*Creep of rag-filled phenolic at average temperature of 195.5° F. (91° C.).* **24**—*Creep of tire-cord-filled phenolic at average temperature of 193.2° F. (90° C.)*

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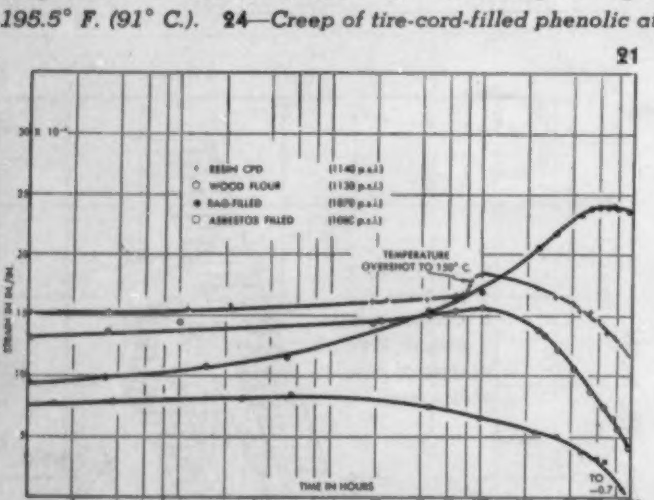

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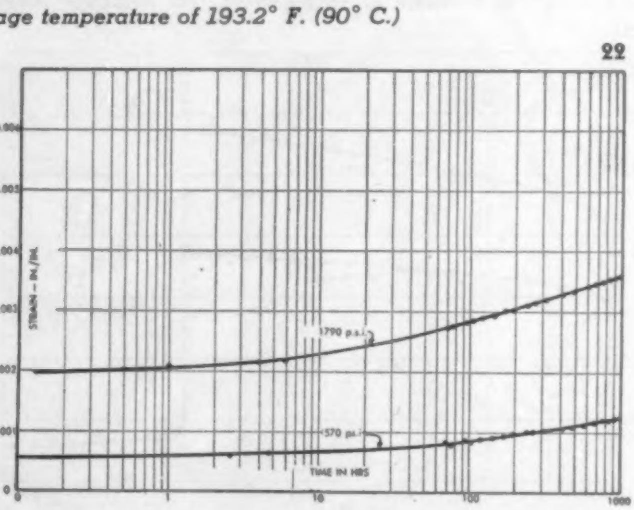

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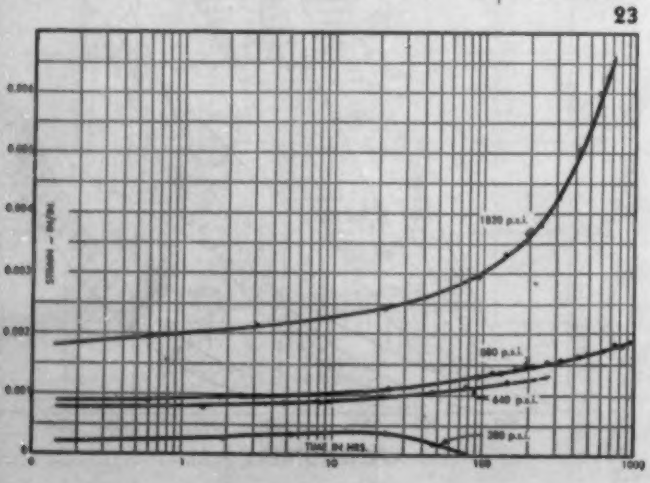

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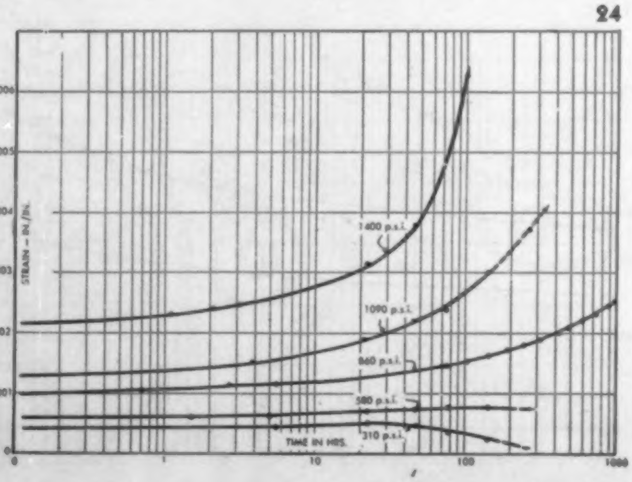

are the creep curves for the previously described phenolic materials at about 190° F. Here the cord-filled specimens at higher stresses, and to some extent the rag-filled specimens, showed a much greater amount of non-recoverable flow than at lower temperatures. However, failures were still more properly described as "brittle" rather than as "ductile."

Figure 28 shows total creep after 1000 hr. plotted against stress for 190° F. (dotted lines), and for 77° F. (solid lines). As might be expected, each of the room temperature curves is shifted toward higher total creep when the temperature is increased to 190° F. Although the data available at present did not warrant plotting creep for stresses below about 500 p.s.i., there is good evidence that the 190° F. curves cross the stress axis and become negative for stresses lower than this. Apparently the tendency to shrink predominates under conditions such as these.

Discussion of results

It is interesting to note that the tendency to creep, as measured both by the total deformation and by the creep rate after 500 hr., may be correlated to a fair degree with the notch sensitivity of the material and with its impact strength as measured by an energy-to-fracture method.[21] Table II lists these properties. The notch sensitivity refers to the ratio of the impact strength (energy-to-fracture) of the unnotched to that of the notched specimen. Such a correlation is to be expected because ability to deform plastically makes possible a relief of local stress-concentrations in the vicinity of the notch.

As already pointed out, the creep and recovery curves of different materials resemble each other in that (a) they all show an initially high creep rate which decreases approximately inversely with time; (b) they all show a tendency to approach a constant rate of creep after long times. Mathematically, this behavior may be described by the differential equation

$$\frac{d\epsilon}{dt} = \frac{A}{t} + B$$

or, in the integrated form,

$$\epsilon = A \log t + Bt + C$$

where ϵ = strain, t = time and the constants A, B and C are

[21] D. Telfair and H. K. Nason, "Impact Testing of Plastics—I. Energy Considerations," A.S.T.M. Preprint No. 88 (June A.S.T.M., 1943).

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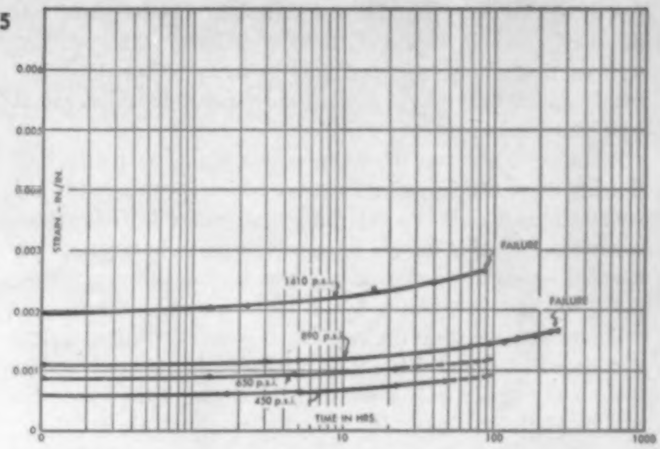

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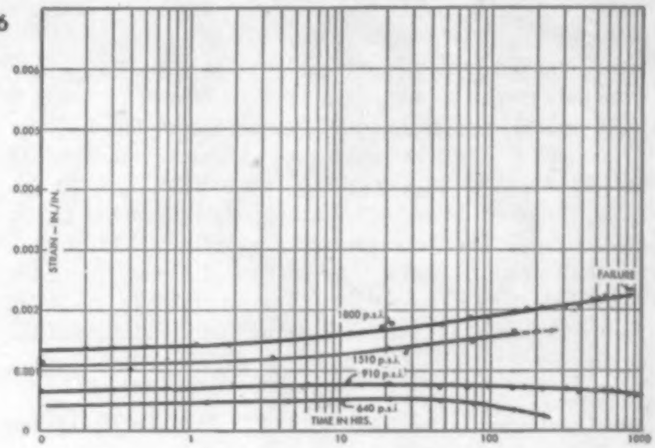

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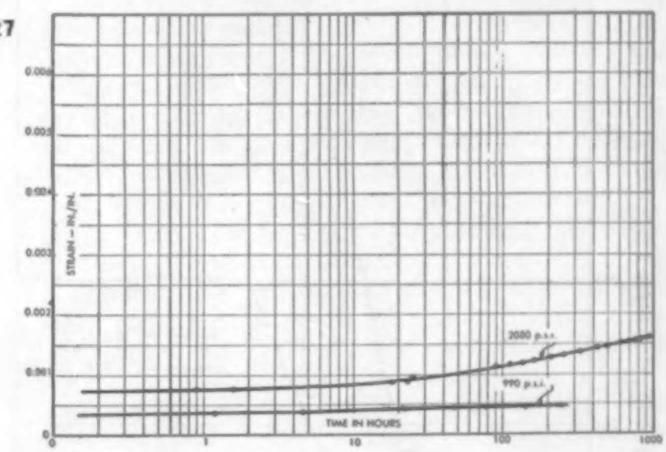


25—Creep of pure phenolic resin, average temperature 188.9° F. (87° C.). 26—Creep of asbestos-filled phenolic, average temperature 192.1° F. (89° C.). 27—Creep of mica-filled phenolic, average temperature 193° F. (90° C.)

TABLE II.—CORRELATION BETWEEN CREEP RATE, TOTAL CREEP, NOTCH SENSITIVITY AND IMPACT STRENGTH OF PHENOLIC PLASTICS AT 77° F.

Material	*Approximate creep rate after 500 hr. at 1800 p.s.i.*	*Average total creep after 1000 hr. at 1800 p.s.i.*	*Notch sensitivity*[a]	*Energy-to-fracture impact strength*
	10^{-8} in./in./hr.	*10^{-4} in./in.*		*ft.-lb./in.*
Cord filled	64	13.2	1.1	1.60
Rag filled	53	9.6	1.1	1.10
Woodflour filled	37	7.9	3.6	0.11
Resin compound	22	4.3	12.0	0.05
Asbestos filled	13	3.2	4.1	0.06
Mica filled	2	0.6	5.0	0.10

[a] The ratio of the energy-to-fracture impact strength of a notched specimen to that of an unnotched specimen of depth equal to the depth under the notch

functions of the stress and of the material. Leadermann[8] has discussed creep in terms of these equations. We shall not attempt to evaluate the constants in terms of our data, but merely point out that our data correspond to this general type of behavior.

Perkuhn[9] also uses a strain versus log time method of plotting data, and interprets a curve which is concave toward the strain axis as indicating danger of failure in finite time. In accord with this, he defines creep strength in terms of the stress below which the strain versus log time curve will be either straight, or concave toward the time axis. Our results indicate, however, that for many materials no practical danger of failure is present for curves with considerable curvature toward the strain axis even though, theoretically, such behavior, if it continues indefinitely, must produce failure. It also is worthy of note that the type of curvature exhibited during the first 400 or 500 hr. seldom continues during the 500 to 1000 hr. interval. This curvature may either decrease or increase, and it frequently does the latter for the higher loads. Consequently, it may not be safe to draw conclusions from data carried to only a few hundred hours.

At present, time-to-fracture data are incomplete both for room and for elevated temperatures. However, the trend for the six phenolics in question is given in Table III. In this table, the stress below which no practical danger of failure exists, is estimated between rather wide limits. In general, the limiting stress varies between 23 and 45 percent of the short-time tensile strength of the material in question. Figure 20 shows that even though the limiting stresses of the organic-filled materials are as high, or higher, than those of

28—*Total creep after 1000 hr. at 77° F. (solid lines) and 190° F. (dashed lines)*

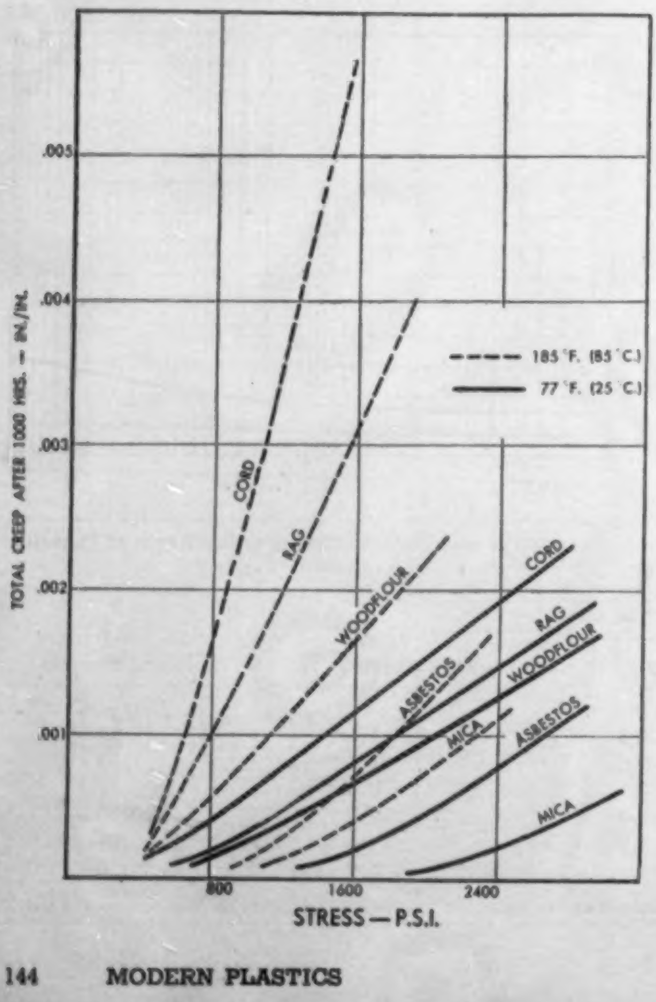


Table III.—Long-Time Tensile Strength of Phenolic Plastic at 77° F. and 50 Percent Relative Humidity

Material	Short-time tensile strength A.S.T.M. D638–41T	Estimated limiting long-time tensile strength	Percentage of short-time strength
	p.s.i.	p.s.i.	%
Cord filled	6000	2400–3000	45
Rag filled	6100	2400–3000	45
Woodflour filled	6100	2000–2500	36
Resin compound	8900	1600–2400	23
Asbestos filled	5700	1900–2300	37
Mica filled	5400	1600–2100	34

the others, the total creep or delayed deformation produced by these stresses is considerably greater. Both at room and at elevated temperatures, fracture of cellulose-filled materials occurred within a few hours after loading for stresses above what appeared to be a fairly narrow range of stresses. Below this stress range, 1000 hr. or more produced no failure. More data are being taken on time-to-fracture, and these results will be reported later.

Conclusions

Conclusions may be briefly tabulated as follows:

1. If proper methods and technics are used, resistance wire strain gages of the SR-4 type are well suited to the measurement of creep in thermosetting plastics.

2. The total creep in 1000 hr. and creep rate after 500 hr. of loading depend to a considerable degree upon the type of filler used in molded phenolic plastics. As might be expected, the creep of inorganic filled materials is much less than that of materials with organic fillers of the cellulose type.

3. Both total creep and creep rate increase from two- to four-fold with an increase in temperature from 77 to 190° F.

4. The long-time tensile strength at room temperature varies roughly between 23 and 45 percent of the short-time strength, depending on the filler used.

5. Continued heating tends to slowly shrink molded phenolic plastics. The magnitude of this shrinkage is of the same order as the extension produced by low stresses (about 500 p.s.i.) and is less for unfilled resin and mica-filled material than for the other materials tested.

Acknowledgment

The room temperature data are to a large extent the product of the patience and industry of James H. Watt. John Westberg and Walter Gailus have contributed greatly to the work at elevated temperatures. We are also indebted to A. C. Ruge for his cooperation in the development of a suitable strain gage for making creep measurements at elevated temperatures.

Appendix

Likely sources of error for creep measurements made with SR-4 gages.—Figure 29 represents the dummy gage circuit (at left) and the measuring gage circuit (at right). These two circuits act as two arms of a Wheatstone bridge. When the bridge is balanced, either binding post, C, is at the same potential as the point D, and no current flows through the galvanometer. A change in the resistance of the gage, R_g, will destroy this balance, and a new micrometer or decade setting must be made to restore balance. However, a change in R_g is not the only way in which a new micrometer or decade setting can be necessitated. By referring to the circuit diagram, it *(Please turn to page 174)*

Creep and time-fracture strength of plastics under tensile stresses

by BERNARD CHASMAN*

THE use of plastic materials in aircraft may result in unusually high deformation, compared to metals, due to the comparatively low modulus of elasticity and to creep and fracture which may occur under continuous low load even at room or slightly higher temperature. Knowledge of the creep and time-fracture properties of plastics, therefore, would make possible the more efficient use of these materials.

This investigation was made at room temperature on two types of commercially available thermoplastic plastic materials—methyl methacrylate sheet and cellulose acetate sheet, used extensively for transparent enclosures—and two types of thermosetting plastic materials—fabric-filled and paper-filled laminated phenolic sheet, used for non-structural applications. Time-deformation and time-fracture curves are included up to at least 1000 hr., with the exception of cellulose acetate which was discontinued after 800 hr. due to the inability to control the test conditions. However, the time-deformation curves for the latter are presented because they show a general trend of time-deformation and indicate the effect on this material of changes in temperature and humidity.

The time-fracture data indicate that the long-time loading strength, namely, the stress that could be sustained for at least 1000 hr. of continuous dead loading without failure, was higher for the thermosetting materials than that for the thermoplastics in percentage of the short-time or standard tensile strength, and with considerably less deformation. The time-deformation data indicate that the creep of the thermoplastic materials was considerably higher than that of the thermosetting plastic materials after the same duration of loading in the ranges of stresses covered in these tests.

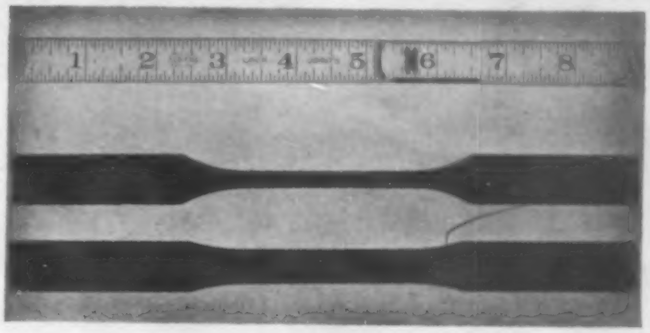
Approximately two years had elapsed between the short-time tensile tests previously reported[1] and similar tests reported herein, on specimens taken from the same sheets and in the same direction. This aging does not appear to have affected the tensile strength of laminated phenolic materials or the methyl methacrylate. There was indicated, however, a slight increase in modulus of elasticity.

Materials

The methyl methacrylate plastic was transparent, water white, cast sheet, $^1/_{16}$ in. thick, conforming to U. S. Army Specification No. 94-12014-B.

The cellulose acetate material (Monsanto 2050 TVA) was a yellowish tint transparent sheet, $^1/_{16}$ in. thick, conforming to Army Air Corps Specification No. 12025-B, now Army Air Forces Specification No. 12025-B.

The laminated phenolic sheets, $^1/_{16}$ in. thick, were procured commercially and conformed to U. S. Army Specification No. 71-484, now superseded by Federal Specification HH-P-256. The grade *L* material consisted of woven fabric cloth, less than 8 oz. per sq. yd., impregnated with phenol-formaldehyde resin and bonded at a high pressure. The grade *XX* material consisted of a paper filler, impregnated with approximately 50 percent phenol-formaldehyde resin and bonded at a high pressure.



1—*Test specimens, Types I and II*

Procedure

Short-time tensile tests.—Except as otherwise noted, test specimens were prepared and tested in accordance with the procedure which is now specified in Federal Specification L-P-406, "Plastics, Organic; General Specification (Methods of Tests)." Tensile tests were made on Type 1 specimens for sheet material. All specimens for these tests were taken in the same direction, previously described as longitudinal.[1] The reduced or gage section of the specimens was milled crosswise from sheared $^3/_4$-in. wide blanks with a special milling cutter having the contour of the gage section. The reduced section was $2^1/_4$ in. long, allowing for a 2-in. gage section. The milled edges were cleaned with successively finer abrasive paper and finished with No. 16 emery polishing paper to remove burrs or scratches transverse to the axis of the specimen. The faces of the specimen were the original surfaces of the sheet material.

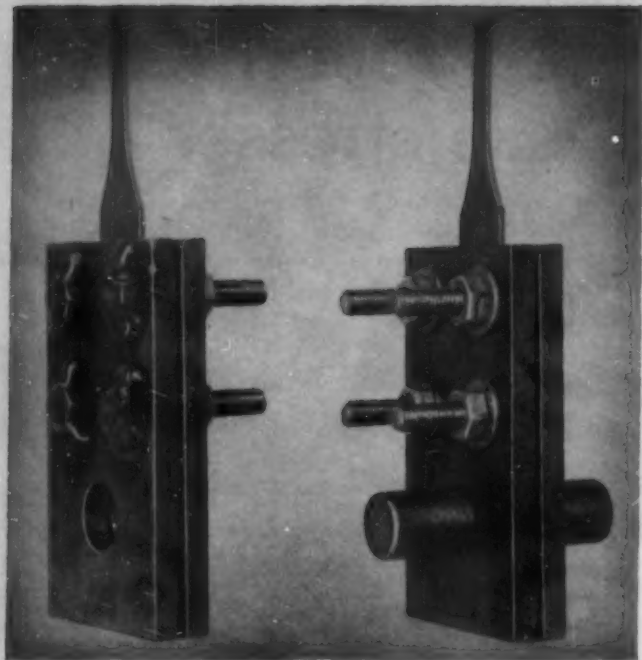
Additional tests were made on subsize longitudinal specimens taken from the laminated phenolic sheet materials. The contours of the subsize tensile specimens conformed to Type 2 in the above specification. Both types of tensile specimens are shown in Fig. 1. All specimens were conditioned 48 hr. at 77 ± 2° F. and 50 ± 2 percent relative humidity, as required in the above specification

The methyl methacrylate specimens were tested in a screw-type, lever weighing, testing machine rated at 20,000 lb., and adjusted to the 2000-lb. scale. The handwheel drive was used to apply load to slightly past the 0.2 percent offset yield strength, during which deformation was recorded, and the test continued to the ultimate with the motor drive at approximately 0.10 in. per min. head travel under load.

The laminated phenolic specimens were tested in a hydraulic testing machine rated at 20,000 lb. and adjusted to suitable capacity. The rate of head travel up to slightly

* Materials Laboratory, Army Air Forces, Wright Field.

[1] T. T. Oberg, R. T. Schwartz and D. A. Shinn, "Mechanical Properties of Plastic Materials at Normal and Subnormal Temperatures." A.C.T.R. No. 4648 (June 1941); MODERN PLASTICS 20, 87–100, 122, 124, 126, 128 (April 1943).



2—*Grips for creep test*

past the yield point at 0.2 percent offset, was governed by the ability to read the strain gage, and continued to the ultimate at approximately 0.15 in. per min. head travel under load, using a calibrated head travel pacer mechanism.

Specimens of each material were tested in the same testing machines used for previous tensile tests[1] and at the same rate of head travel for purposes of comparison. Therefore, the rates of head travel do not necessarily conform but are within close agreement with those now specified in Federal Specification L-P-406. All tensile specimens were held in Templin self-aligning grips. Deformation was measured with an Olsen Last-Word Extensometer, 2-in. gage length, with the smallest scale division representing 0.0001 in. deformation or 0.00005 in. per in. strain. Elongation was measured just before failure with an Olsen elongation caliper reading directly in percent elongation for a 2-in. gage length. Cross-sectional areas were computed from the average of several measurements of width and thickness at the reduced section measured with micrometer calipers to the nearest 0.0005 inch.

Long-time tensile tests.—Time-fracture and creep tests were made in a test room maintained at constant temperature and relative humidity under dead or continuous tensile loading, in accordance with Federal Specification L-P-406. The tests on methyl methacrylate sheet were made on standard, Type 1, specimens in the test room maintained at 77 ± 2° F. and 50 ± 5 percent relative humidity. Several tests on methacrylate were made at 79 ± 5° F. and 60 ± 10 percent relative humidity, and are so marked. All tests on fabric- and paper-filled phenolic materials were made on the subsize specimens with contours conforming to the above specification, Type 2, with a $^1/_4$-in.-wide gage section to decrease the loads necessary to develop the desired stresses. The fabric-filled material was tested at 75 ± 3° F. and 55 ± 5 percent relative humidity, and the paper-filled material at 78 ± 2° F. and 43 ± 5 percent relative humidity. The temperature and humidity were taken with a wet and dry bulb temperature recorder, and a bi-metallic strip and hair-type temperature and humidity recorder. The variations of the humidity and temperature conditions for all tests were unavoidable and resulted from the load limitations of the air-conditioning equipment.

Tests were run for 1000 hr. duration where possible and were extended beyond this as much as the time would afford. The specimens were mounted in special grips as shown in Fig. 2. Each grip was so designed that the four bolts located the centerline of the specimen coaxial with the centerline of the grip and the suspension pin. The latter acted as a stop for the end of the specimen to ensure comparable gripping area of the specimen and comparable distance between grips. The inside edges of each grip were relieved to a $^1/_8$-in. radius to minimize stress concentration when the bolts were tightened and the specimen was under tensile load. The bolt heads were tack welded in place so that it was only necessary to loosen the nuts to separate the grips.

Each specimen was suspended vertically between the two horizontal, parallel wooden beams, as shown in Fig. 3, by means of a 1-in. diameter cylindrical steel cross bar, two $^1/_8$-in. thick steel plates and the pin in the upper grip. The calibrated weight hanger and necessary calibrated weights were suspended from the pin in the lower grip by a loop of flexible cable. Wooden blocks were put under the weight hanger to decrease the distance between floor and hanger to a minimum, to prevent jarring of the setup when a fracture occurred. The wooden frame was sufficiently stiff and heavy to prevent reaction on other specimens when any specimen failed.

Mounted on one of the parallel wood beams were electric time-meters and switches operated by a trip cord through the frame of the weight hangers. When fracture of a specimen occurred, the falling weights caused the trip cord to pull the switch and so stop the time-meter. The junction boxes permitted removal of any temporarily unused time-meters for other use, without interfering with other tests.

3—*Creep test set-up*

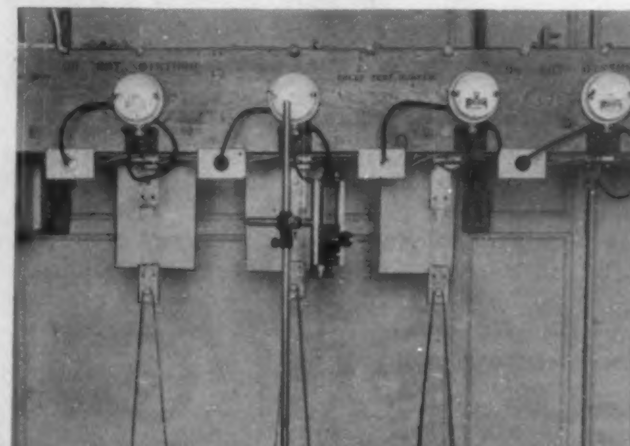


Table I.—Comparison of Short-Time Tensile and Long-Time Tensile Time-Fracture Data

Material	Yield strength, 0.2 percent offset	Ultimate strength, average	Elongation at fracture	Modulus of elasticity	Time-fracture strength 1000 hr.	Time-fracture as percentage of ultimate
	p.s.i.	p.s.i.	%	p.s.i. $\times 10^{-6}$	p.s.i.	%
Methyl methacrylate						
This report	5,260	8,690	5	0.407	3,900	45
Previous report[a]	5,600	8,600	5	0.380		
Grade *L* phenolic laminate						
This report	9,400	16,520	2	1.45	11,000	67
Previous report[a]	9,200	16,460	2	1.34		
Grade *XX* phenolic laminate						
This report	14,000	16,540	1	1.70	11,000	67
Previous report[a]	13,700	16,770	2	1.57		
Cellulose acetate						
Previous report[a]	3,600	5,860	38	0.217		

[a] See footnote 1. These tensile test results were from tests run approximately two years prior to those reported herein, on specimens taken from the same sheets of material.

The load was gradually applied to the specimen with a long length of steel tubing used as a lever. The weight hanger with weights was lifted up so the loop could be put in place. The loaded hanger was then slowly lowered, transferring the load smoothly to the specimen.

Creep tests.—In taking creep test data, measurements of deformation at no load, immediately after load and at regular intervals thereafter under continuous load, were made between two parallel gage lines drawn 2 in. apart on the gage section of the specimen. These lines were drawn with India ink to which had been added a suitable amount of Aerosol OT, as a wetting agent, to produce a smooth, unbroken gage line. A cathetometer (Fig. 3) consisting of a short focus telescope with 90° cross hairs, in a micrometer slide, mounted on a leveling tripod base, was used to measure deformation between the two lines on the specimens of the laminated phenolic and cellulose acetate materials. The smallest division on the drum of the micrometer slide was equal to 0.0005-in. motion of the slide. Increments of 0.0001 in. were readily estimated. A leveling bubble was mounted on the slide frame so the slide could be adjusted to the vertical plane. The tests on the methyl methacrylate material were run before the cathetometer became available and, therefore, readings of deformation were made with a scale reading to 0.01 inch. This was sufficiently accurate for this material as the deformation was relatively large.

Each point plotted in the original creep and time-fracture curves was the average of several measurements of the distance between gage lines, from which the initial distance under no load, similarly determined, was subtracted. The curve lines were faired through the various points to form a smooth curve. To simplify presentation, the points in both the creep and time-fracture curves shown herein for the methyl methacrylate and the laminated phenolic materials were omitted, and only the curve lines are shown.

Discussion of results

Creep tests.—In the long-time tests the loads required to develop the desired tensile stresses in the standard $^1/_2$-in. wide tensile specimen, Type 1, of the laminated phenol-formaldehyde materials were too large to be handled conveniently as dead loads. Therefore, tensile specimens with $^1/_4$-in. wide gage section, standard Type 2, were tested. Short-time tensile tests on Type 1 and 2 specimens indicated that the change in width of gage section had no apparent effect, and creep tests were made on the Type 2 specimens.

Tensile stressing was used because it develops a uniform stress across the area as contrasted with the bending or torsional type in which the stresses on the outer fibers are the highest. The accuracy of reading the deformation, which is less than in bending or torsion, is greatly increased by the use of the cathetometer. The deformation measured with the cathetometer is subject to a positive error equal to the creep that occurred during taking of the readings. The initial readings, taken immediately after application of load, were subject to the greatest positive error because the creep rate is probably maximum at that time. Inasmuch as it took only approximately 0.1 hr. to take the several

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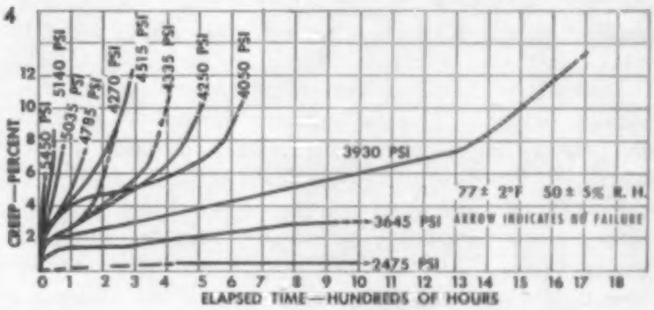

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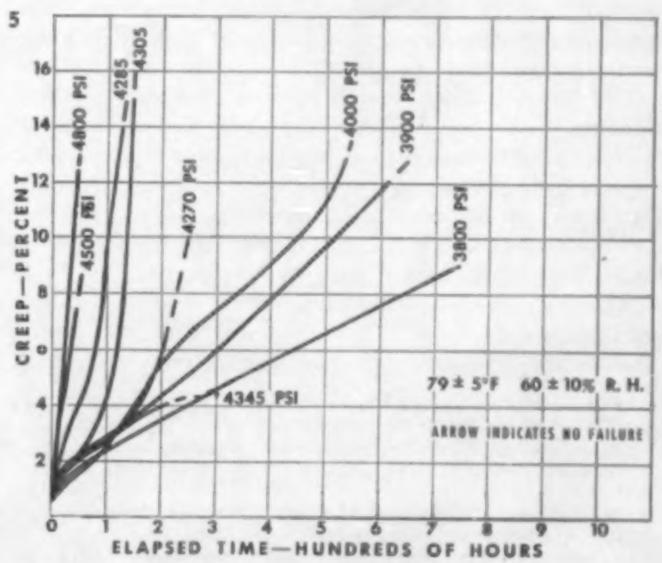
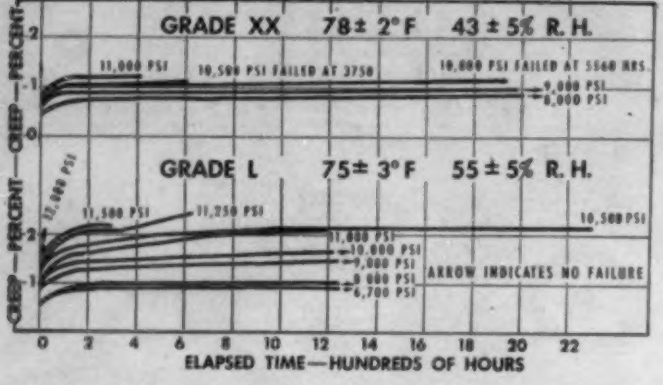


4—Creep curves of methyl methacrylate sheets 1/16 in thick at 77 ±2° F. and 50 ±5 percent relative humidity.
5—Creep curves of methyl methacrylate 1/16 in. thick at 79 ±5 F. and 60 ±10° percent relative humidity



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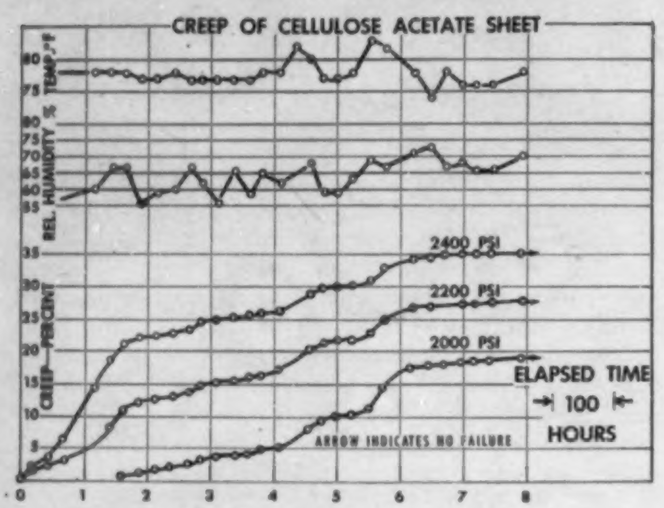

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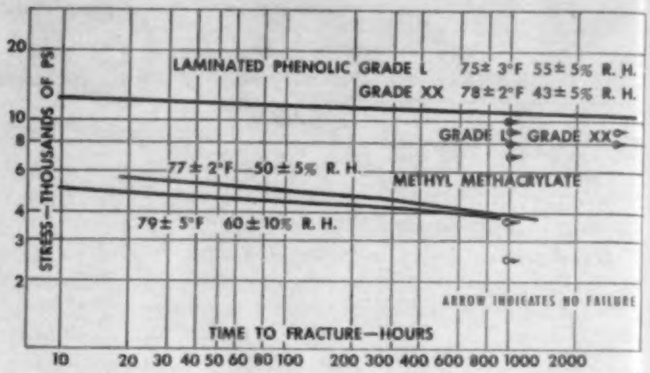

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6—Creep curves of laminated phenolic 1/16 in. thick. 7—Creep curves of cellulose acetate sheet. 8—Tensile time-fracture curves

readings in a group to be averaged, this error is probably quite small.

The shape of the creep curves, shown in Figs. 4 to 7 inclusive, is similar to those reported for various materials by other investigators, for the tensile-type creep test of plastics,[2–4] for the bend-type creep test of plastics,[5, 6] and for the tensile-type creep test of metals.[7]

The creep curves may be divided, roughly, into three stages of creep. The first stage is a range of high creep rate that decreases rapidly and, after a transition, enters the second stage of lower, almost constant creep rate. The creep rate then increases in the beginning of the third stage and continues to do so until failure. The complete three stages may not always be developed as they appear to be a function of the stress, and the time under load. For brittle or low ductility materials such as the paper-filled phenolic laminate, the development of the third stage may be difficult due to the effects of any transverse marks, irregularities or imperfections that may not have been completely removed in finishing the surfaces of the test specimen.

The complete three-stage curve results from tests run at medium stresses in the range for a given material. As the stresses are increased for the material, the creep rate in the second stage increases and the length of this stage decreases until, at comparatively high stresses, only a point of inflection between the first and third stages remains. As the stresses are decreased, the creep rate in the second stage decreases, and the length of this stage increases, until at comparatively low stresses the third stage does not appear within the limits of this investigation, and the stress is maintained indefinitely. The length of the first stage does not appear to vary appreciably with stress.

The creep curves shown are drawn as solid lines from initial point under load to the last point at which deformation was read, and extrapolated, shown as a dashed line, to time of failure. However, the deformation at the time of failure was approximated from the trend before and up to the last deformation reading.

The effects of variation in temperature and relative humidity on the creep of methyl methacrylate and cellulose acetate plastics are shown in Figs. 4, 5 and 7. Comparison of the curves in Figs. 4 and 5 indicates that increased variation in test conditions results in a considerable increase in the creep and decrease in time to failure for the methacrylate plastic with more variation in the development of the creep curves. The creep of cellulose acetate appears to vary directly and considerably with change in temperature and relative humidity. The long-time loading tests on the cellulose acetate were discontinued after approximately 800 hr. maximum of dead loading, without failure, due to the inability to control and maintain the test conditions. The deformation of the specimens tested developed approximately uniformly over the gage section. It was noted that as the deformation increased, the gage section became cloudy white when viewed by transmitted light. This coloring remained after the load was removed.

Tensile time-fracture tests.—The time-fracture data are shown in Fig. 8, on log-log coordinates. Other investigators report similar curves for thermoplastic and thermosetting materials, and plain carbon and alloy steels. These data indicate that the fabric- and paper-filled laminated phenolic materials, grades *L* and *XX*, would sustain a stress of approximately 11,000 p.s.i., 67 percent of the short-time tensile strength, for 1000 hr. before fracture, under the test conditions. At the time of the writing of this report, one specimen of paper-filled phenolic material, Grade *XX*, stressed to 10,000 p.s.i., failed after 5560 hr. of dead loading. These data are not shown on Fig. 8. The methyl methacrylate material, under the least variable (*Please turn to page 176*)

[2] H. Perkuhn, "The Creep of Laminated Synthetic Resin Plastics," N.A.C.A. Tech. Memorandum No. 995 (1941).

[3] W. N. Findley, "Mechanical Tests of Cellulose Acetate," Proceedings A.S.T.M. *41*, 1231–1245 (1941); Modern Plastics *19*, 57–62, 78 (Sept. 1941).

[4] W. N. Findley, "Creep Tests on Cellulose Acetate," Proceedings A.S.T.M. *42*, 914–926 (1942); Modern Plastics *19*, 71–73, 114 (Aug. 1942).

[5] J. Delmonte and W. Dewar, "Factors Influencing Creep and Cold Flow of Plastics," ASTM Bulletin No. 112, 35 (Oct. 1941); Modern Plastics *19*, 73–79, 110 (Oct. 1941).

[6] J. Delmonte, "Permanence of Physical Properties of Plastics," Transactions A.S.M.E. *62*, 513–524 (Aug. 1940); Modern Plastics *17*, 49–52, 78, 80, 82 (May, 1940); 65–68, 84, 86 (June 1940).

[7] J. J. Kanter, "Interpretation and Use of Creep Results," Trans. Am. Soc. for Metals *24*, 870–918 (Dec. 1936).

TECHNICAL BRIEFS

Abstracts of articles on plastics in the world's scientific and engineering literature relating to properties and testing methods, or indicating significant trends and developments.

Engineering

TEXTILE-PLASTIC COMBINATIONS. C. W. PATTON. Am. Dyestuff Reptr. *32*, P513–23 (Nov. 22, 1943). Various types of cotton, rayon and cotton-rayon fabrics and woolen flannel were bonded to sheets of 3 grades of vinyl chloride-acetate resin, vinyl butyral resin, vinyl butyral resin combined with a thermosetting resin and cellulose acetate. The force required to peel the fabric from the plastic was determined. In general the vinyl butyral resin and the woolen flannel, cotton corduroy and cotton twill gave the strongest bonds, and the rayons gave the weakest bonds.

DRYING OF IMPREGNATED FABRICS. B. N. Rutovskii and A. N. Levin. Trudy Moskov. Khim.-Tekh. Inst. im. Mendeleeva *1940*, No. 7, 49–91. The amount of resin transformed into the insoluble state during drying should not exceed 10 percent of the total. There are no breaks in the drying velocity curves for impregnated fabrics; the rate of drying decreases continuously. The rate of drying is expressed by the following equation: $dS/dT = [(0.44\ S^2 + 3) \times 10^{-4}] / [S^2/(V + 4) + 10]$ g./sec./sq. cm. where S is the percent of volatile material in the fabric and V the velocity of the air in m./sec. at 140° C. These experiments led to the production of a laminated phenolic plastic with improved properties and to acceleration of production.

THE THEORY AND PRACTICE OF INDUSTRIAL ELECTRONIC HEATING. J. P. Jordan. Gen. Elec. Rev. *46*, 675–83 (Dec. 1943). A discussion of electronic heating as applied to induction heating of metals and to the dielectric heating of nonmetallic materials such as plywood, plastics and foods. Although the equipment for both applications are somewhat similar, their methods of heat generation and its effect on the charge are widely different. The theory is explained and the equipment is described in detail.

TRANSFORMATION OF CASEIN WITH FORMALDEHYDE. H. Nitschmann, H. Hadorn and H. Lauener. Helv. Chim. Acta *26*, 1069–98 (1943). A method for determining the formaldehyde content of casein plastics is described. The rate of absorption of formaldehyde from solutions and from vapor by casein was studied. Although the rate diminished greatly with time, the absorption had not ceased after 30 days. The formaldehyde content depends on the length of exposure to the formaldehyde and the length of washing or exposure to air after hardening. At 50 percent relative humidity, casein which is hardened with formaldehyde gas absorbs less water than casein which is hardened with formaldehyde solution. The maximum swelling resulting from immersion in water is less with gas-hardened casein than with solution-hardened casein. The least swelling is attained when the formaldehyde content of the casein plastic is between 1 and 1.5 percent. Formaldehyde produces a principal valence bond between the protein molecules; this is responsible for the increased resistance to water.

HIGH-FREQUENCY HEATING APPLIED TO AIRCRAFT WOODWORK. P. H. Bilhuber and W. Godfrey. Aero Digest *43*, 178–86, 235 (Oct. 1943). The use of high-frequency heating in the actual production of laminated wood aircraft parts is described. Particular emphasis is placed on the difficulties encountered and their solution. A small portable electrode in the form of a gun for "nailing" or "ironing" glue joints is described.

Chemistry

COPOLYMERS OF *p*-CHLOROSTYRENE AND METHYL METHACRYLATE. C. S. Marvel and G. L. Schertz. J. Am. Chem. Soc. *65*, 2054–58 (Nov. 1943). The method of interrupted copolymerization of mixed monomers has been used to determine the relative rates at which *p*-chlorostyrene and methyl methacrylate enter a growing copolymer chain. This ratio was 1.46 and remained constant when the temperature, solvents and relative concentrations of the monomers were varied. The same ratio was obtained when *m*-chlorostyrene was substituted for its para isomer. Both *m*- and *p*-chlorostyrenes polymerize more rapidly in bulk than styrene when mixtures of the chlorostyrene and styrene were copolymerized. The molecular weights of chlorostyrene-methyl methacrylate copolymers obtained when the reaction was 9 percent complete were in the same range as were those when the reaction gave higher conversions. Polymers prepared from mixtures containing more than one mole of dimethyl fumarate or diethyl maleate per mole of *p*-chlorostyrene contained less than 50 mole percent of the symmetrically disubstituted ethylenes.

Properties

THEORY OF FILLER REINFORCEMENT IN NATURAL AND SYNTHETIC RUBBER. J. Rehner, Jr. J. Applied Physics *14*, 638–45 (Dec. 1943). A general theory of filler reinforcement is developed by determining the stresses occurring in and about a spherical particle imbedded in a rubberlike medium subjected to an applied tension. For a system containing a single particle rigidly attached to the adjacent medium, an application of the theory of elasticity shows that, for infinitesimal deformations, the stress components within the particle are independent of the radial distance from the origin, taken at the center of the particle. The stress components at a given point in the surrounding medium depend on the elastic constants both of the particle and of the medium, on the radius of the sphere, on the distance from the origin and on the angle between the direction vector and the applied tension. Expressions are given for the average stresses in media containing many independent particles.

MICROSCOPY OF PLASTICS. C. Gordon. Chemistry and Industry *62*, 420 (Oct. 30, 1943). A technique is described by which microscopic sections of fiber-reinforced phenolic plastics can be examined by transmitted light, and the resin and fibers differentially stained. It is suggested that there is some penetration of resin into the fiber wall where it forms a resin-fiber combination. The evidence for this is based upon the alteration of the staining reactions of fibers in a board, alterations in their optical properties and the destruction by the resin of artificially produced fluorescence in fibers examined under polarized ultraviolet light. Micro-test pieces can be pulled under the microscope and the type and course of the failure can be shown to depend largely upon the amount of penetration of the resin into the fiber. The degree of resin-fiber association is modified by the type of fiber and the type of resin; but the solvent, and hence the colloidal properties of the resin, may be a most important factor.

Testing

INFRARED SPECTROSCOPY. R. B. Barnes, U. Liddel and V. Z. Williams. Ind. Eng. Chem., Anal. Ed. *15*, 659–709 (Nov. 1943). The theory of infrared absorption and the relation of infrared absorption to molecular structure are discussed. Detailed descriptions of infrared absorption techniques useful in analysis are given. Representative spectrographs of 363 organic compounds are presented. This list includes most of the organic solvents and many of the raw materials used in the plastics and protective coating industries. Spectrographs for films of polyisobutylene, polyvinyl alcohol, polyvinyl acetate, polyethyl acrylate, hexaethylene glycol maleate, octodecanediol maleate, tetra acetyl glucose and ethyl cellulose, and for tung oil, linseed oil, neat's-foot oil, soya bean oil, methyl esters of tung oil, and methyl and ethyl esters of linseed oil are given.

PLASTICS DIGEST

This digest includes each month the more important articles of interest to those who make or use plastics. Mail request for periodicals directly to publishers.

General

PLASTIC BODYWORK. W. Nichols. Automobile Eng. *33*, 361–5, 405–10, 493–8 (Sept., Oct., Nov. 1943). A general review of the principal materials and methods used in the plastics industry. The materials and methods which appear to be useful in plastic bodywork are emphasized. Laminated plastics, particularly of the phenolic type, plastic plywood and transparent plastics are discussed. Emphasis is placed on their strength properties and methods of forming or molding. Various adhesives for bonding plywood are discussed. The proposed design of a 2-seater passenger car body is given. It is proposed that the body be made of molded plywood and various details of construction are postulated. Transparent methyl methacrylate resin is proposed for the windshield and a section of the roof.

A POSTWAR CONTEST. J. M. Weiss. Chem. Eng. News *21*, 2020–21 (Dec. 10, 1943). Possible channels for the consumption of light metals, steel and plastics in the postwar world are discussed. Suggested fields are the transportation and building industries. The full production capacity of the light metal and plastics industries will not seriously affect steel.

Materials

BORATED RESINS. E. P. Irany. Ind. Eng. Chem. *35*, 1290–2 (Dec. 1943). Boric acid reacts readily with macromolecular substances such as cellulose esters and ethers and partially hydrolyzed polyvinyl esters and acetals, which contain a plurality of hydroxyl groups per molecule. The products formed are spatially linked, insoluble, infusible boric acid esters or ester-like association compounds. These compounds are hydrolyzed by mere contact with water or alcohols and regenerate the original thermoplastic resin without change. Various uses can be made of this effect—for example, in the production of thermoplastic and rubber-like materials in the form of fine powders or in temporary protective coatings; marginal additions of boric acid provide a means of sensitive control of molding materials and in film casting.

WATER EMULSIONS OF POLYVINYL ACETATE. Rubber Age *54*, 133 (Nov. 1943). Water emulsions of polyvinyl acetate containing 60 percent resin are available. They are free-flowing, milky-white and stable. The commercial emulsions contain less than 1 percent of monomeric vinyl acetate and less than 0.3 percent acetic acid. The pH is between 4.5 and 5.5; the pH can be adjusted to 8.0 with triethanolamine or aqueous ammonia. These emulsions are recommended as adhesives for bonding a wide variety of materials such as metals, cellulose products, plastics, leather and cork. Chlorinated rubber and rubber latex may be incorporated with polyvinyl acetate emulsions to produce special adhesives.

SYNTHETIC RUBBER. S. S. Pickles. Automobile Eng. *33*, 201–2 (May 1943). The properties of natural rubber, German Buna S, American Buna S, Butyl rubber, Perbunan, Hycar OR, Neoprene and Thiokols are compared. The properties considered are density, tensile strength, resilience, resistance to abrasion, heat and oil resistance, aging, oxidation, oil resistance, dielectric properties, permeability.

RUBBER RESINS. C. F. Mason. India Rubber World *109*, 249–51, 306 (Dec. 1943). The resin content of various natural rubbers varies from 2 to 80 percent. Their properties and application are discussed. Very little data are available on most of the rubber resins. These resins have been used as plasticizers, in paper sizings, thread impregnants, electric friction tape, insulation pastes, soft adhesives, fly-paper, emulsified textile coatings and linoleum cement.

Molding and fabricating

THE WORKING OF PLASTICS. Am. Machinist *87*, 97–108 (Sept. 1943). The principles of molding and mold construction, types of mold construction, and machining and finishing plastics are discussed.

Applications

ADHESIVE REQUIREMENTS OF THE TEXTILE INDUSTRY. G. B. Cloran. Rayon Textile Monthly *24*, 422–3 (Aug. 1943). Lacquer-type resin adhesives have replaced fish glue for lining shuttles with fur. Paperboard tubes are made with a vegetable dextrin liquid glue. Resin adhesives and water-resistant vegetable adhesives are used to seal and label fiber cases; the resin adhesives are used on cases intended for export. Permanently flexible thermoplastic resin adhesives are used for splicing carpets. Synthetic resin, lacquer, rubber and cold-water-swelling dry adhesives which possess high adhesive power and permanent flexibility are used in textile printing.

PROGRESS REVIEW ON NEW USES FOR NYLON. Rayon Textile Monthly *24*, 457–8 (Sept. 1943). Nylon filaments are being used to make parachute cloths of all types, tent fabrics, filter cloths for blood plasma, ropes for aircraft pickup, gliders and mountain climbers, shoe laces, tire fabric and bristles for brushes. Nylon fabric impregnated with neoprene is used for diaphragms in airplane engine carburetors. Nylon is also being used in form of tubing, film and molded articles.

SEALING TUBE ENDS WITH PLASTIC. Iron Age *152*, 65 (Nov. 4, 1943). A hot melt plastic, "Plastalloy," is used as a protective coating to seal the ends of tubing, to cover threads of equipment and to hold small bearings and bushings in position. The plastic is easily stripped from the parts after the coating has served its purpose and may be reused.

FORMING ACRYLIC RESIN SHEETS WITH PLASTIC DIES. K. J. Leeg. Iron Age *152*, 68–70 (Sept. 9, 1943). Cast phenolic resins with asbestos filler are used to make dies for forming parts from transparent plastic sheet. Dies up to about 4 ft. long are in use and have given better service than wooden forms. The procedure for making plastic dies is described in detail.

"CYCLEWELD" TECHNIQUE FOR JOINING OF AIRCRAFT PARTS. F. M. Reck. Aero Digest *43*, 183–7 (Nov. 1943). Applications and properties of bonds made by the Cycleweld technique are described. The process is being used to make many subassemblies such as wing flaps, stabilizers, bomber flooring, heat ducts and modulator boxes. About 40 manufacturers are using the process. The full advantages of this technique will not be utilized until structures are specifically designed for its use.

Coatings

RESIN EMULSION PAINTS. W. H. Butler. Metal Finishing *41*, 743–6 (Nov. 1943). Recent developments in emulsion paints, some of the factors which should be considered in handling these products, and their specific application are discussed. The types of resin vehicles which can be used for resin emulsion paints are 1) phthalic alkyds, 2) non-conjugated drying oils, 3) long oil type, non-conjugated drying oils, and 4) copolymers based on oil-reactive ester resins and non-conjugated drying oils. The latter type can be easily dispersed in equipment available in most paint and varnish plants. The vehicle for the emulsion is produced by copolymerizing the drying oil and oil-reactive resin in a varnish kettle (with no solvent) to a definite viscosity and cooling with water. Dispersion in water is accomplished by stirring in a pony mixer for 30 min. to one hour. The emulsions have a pH of 8.0 to 9.0. The various types of "oil-continuous" and "water-continuous" emulsions are discussed. Emulsifying and wetting agents and stabilizers must be used in formulating satisfactory resin emulsion paints.

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RUBBER-LIKE RESIN. M. A. Youker (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,333,403, Nov. 2. An interpolymer of butadiene-1,3 and a methacrylic acid ester is prepared in the presence of selenium, tellurium or a mixture of these two elements.

ABRASIVE. P. L. Kuzmick (to J. K. Smit and Sons, Inc.). U. S. 2,333,429, Nov. 2. An abrasive body comprising diamond abrasive grains bonded with a cured phenol-aldehyde type resin.

PLASTIC COMPOSITION. L. J Berberich and J. Swiss (to Westinghouse Elec. and Mfg. Co.). U. S. 2,333,513, Nov. 2. A fire-resisting composition comprising polystyrene, a halogenated aryl compound, and the resinous reaction product of maleic anhydride and styrene.

PLASTIC COMPOSITION. W. W. Koch (to Hercules Powder Co.). U. S. 2,333,577, Nov. 2. A composition comprising ethyl cellulose and a phenol having a carbon linkage para substituent and an oxygen linkage ortho substituent as a stabilizer.

PLASTIC SCREEN. C. Strauss (to Arvey Corp.). U. S. 2,333,618, Nov. 2. A woven fabric composed of non-fibrous plastic strands, the filler strands being held in spaced relationship by crossed warp strand pairs.

STENCIL MATERIAL. A. M. Altman and E. J. Shaw (to A. B. Dick Co.). 2,333, 624, Nov. 9. A stencil correction material including a cellulose ether, a non-volatile solvent, a plasticizer, a filler and a lubricant.

POLYMERIZATION. E. C. Britton and W. J. Le Fevre (to Dow Chemical Co). U. S. 2,333,633-4-5, Nov. 9. Unsaturated organic compounds containing halogen, hydrogen, or alkyl substituents and halogen, alkyl-carbonyl, alkoxy-carbonyl-oxy substituents are polymerized by forming an emulsion of the compound with water, a small amount of acid, a per oxygen compound and a ferric compound.

POLYESTERS. R. E. Christ and W. E. Hanford (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,333,639, Nov. 19 An organic compound having a plurality of -NCX groups, wherein X is a chalcogen of atomic weight below 33, is heated with a linear polymer.

ADHESIVE. J. E. Robinson (to American Can Co.). U. S. 2,333,676, Nov. 9. A resin adhesive consisting of vinyl acetate and pentaerythritylabietate resin.

MOLDING. I. C. Schoonover and G. R. Dickson (to Secretary of Commerce). U. S. 2,333,679, Nov. 9. Plastics are protected during molding by providing a medium between the molding surface and the plastic comprising an insoluble salt of alginic acid.

BUILDING UNIT. J. W. Jordan (to Pittsburgh Corning Corp.). U. S. 2,333,723, Nov. 9. A building wall comprising a plurality of glass blocks laid up with mortar joints, and having spaced, marginal, channeled shoulders, the bottoms of which are coated with a layer of vinyl acetal resin which is cellulate to relieve stresses exerted by volume changes in the mortar.

COATING. J. A. Mitchell (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,333,730, Nov. 9. A coating composition comprising a phenol rubber product, a polymer of isobutylene and wax.

POLYAMIDES. H. Ufer (to Alien Property Custodian). U. S. 2,333,752, Nov. 9. High molecular compounds are prepared by subjecting to heat treatment a substance such as acrylic acid and the amide forming derivatives thereof together with a primary monoarylamine.

ION EXCHANGE RESIN. H. Wassenegger (to Alien Property Custodian). U. S. 2,333,754, Nov. 9. Cation exchange resins are prepared by condensing, in alkaline solution, a member of the group of amino-, hydroxy-, and amino-hydroxy-sulphonic acids of the naphthalene series, and a phenol with formaldehyde to the water insoluble stage.

MOLDING MIXTURES. R. Hessen (to Alien Property Custodian). U. S. 2,333,786, Nov. 9. A mass of heat-hardenable synthetic resin and filler is subjected through a heating and compressing zone where it is kneaded, and finally discharged from the heating zone prior to the heat hardening.

POLYVINYL ACETAL. W. O. Kenyon and W. H. McDowell (to Eastman Kodak Co.). U. S. 2,333,796, Nov. 9. A polyvinyl acetal resin substantially free from hydroxyl groups is prepared by completely esterifying with ester groups such as propionate or butyrate, a polyvinyl acetal resin.

POLYVINYL ACETAL RESIN. C. J. Malm and M. Salo (to Eastman Kodak Co.). U. S. 2,333,804, Nov. 9. A polyvinyl acetal resin is prepared by hydrolyzing polyvinyl acetate, adding aldehyde, and increasing the acetic acid content so as to preclude precipitation.

MOLDED ARTICLE. H. Pohle and P. Weikart (to Winthrop Chemical Co., Inc.). U. S. 2,333,816, Nov. 9. Molded articles are prepared from a paste of plastic and water.

POLYAMIDES. G. J. Berchet (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,333,914, Nov. 9. The reaction product of a synthetic linear polyamide and a substance containing an isocyanate group having an oxygen or sulfur substituent.

COATED FABRIC. R. E. Christ and W. E. Hanford (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,333,917, Nov. 9. A fabric coated with a reaction product of an organic polyisocyanate with a linear polyester-amide.

POLYESTER-AMIDE. H. W. Gray (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,333,923, Nov. 9. A polyester-amide is made rubbery by heating at polymerization temperature in the presence of an anhydride of a monocarboxylic acid.

RUBBER HYDROHALIDE. H. D. Minich. U. S. 2,334, 022, Nov. 9. Rubber hydrohalide film is stretched with the aid of heat.

DENTURES. E. M. Feinberg. U. S. 2,334,078, Nov. 9. A press for molding plastic dentures.

NEW MACHINERY AND EQUIPMENT

★ INDUSTRIAL ENGINEERING CO., INC., CHICAGO, Ill., has recently announced two adjustable twist drill grinding fixtures. These precision-built fixtures are said to assure perfect grinding of all drills from size A-$^1/_4$ in. to $2^7/_8$ inches. The No. 3 fixture, shown in the upper illustration, will handle drill sizes from $^3/_4$ in. to $2^7/_8$ inches. Fixture No. 1, shown in the lower

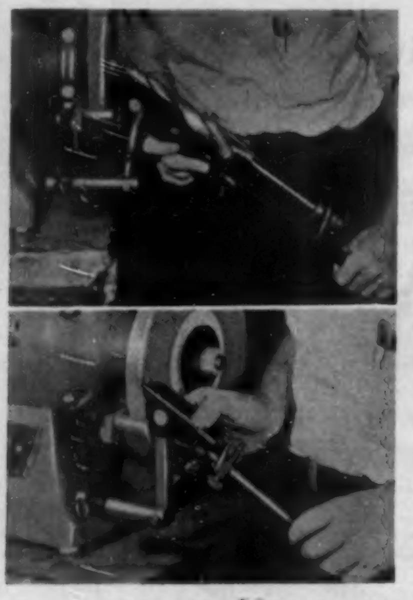


illustration is designed for grinding small drills from A-$^1/_4$ to $^3/_4$ inch. Brackets of this twist drill fixture may be used with Black & Decker, Van Dorn, bench or pedestal grinders. Upon request, the manufacturer will also provide diagrams of special brackets for other types of grinders.

★ AN ACCESSORY DESIGNED TO CONVERT GRINDING and polishing lathes into endless belt grinders and polishers has been placed on the market by the Porter-Cable Machine Co. under the name of the "Back Stand Idler." The company claims that in cases where the original practice was to grind, rough polish and finish on regular wheels, the use of this accessory has eliminated any need for the rough polishing operation. Among the advantages said to be incorporated in this device are "fine thread" adjustments which prevent belt throw-off, a lightweight pulley to minimize inertia at starting, and a hydraulic safety device designed not only to keep the belt tension weight from exerting too great a pressure on the belt when the machine is started but to avoid putting full weight on the belt at once. A wide variety of belts is available, from grit No. 600 fine to No. 24 coarse and any width of belt may be used up to 6 inches. By simply rearranging four parts of the unit, the device can be adapted for right or left-hand operation.

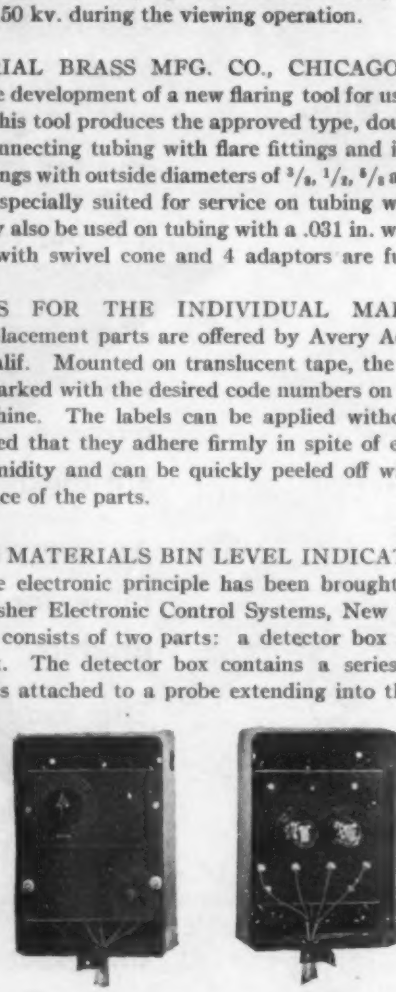
★ A SOLUTION DESIGNED TO REMOVE GUMMED masking paper easily and safely from plastic glass sheets and formed parts now is offered by Turco Products, Inc., Los Angeles, Calif. Aircraft factories have reported considerable difficulty in removing masking paper from plastic parts as the glued paper often vulcanizes to the plastic and the naphtha solvents employed for its removal were found to cause crazing of the plastic. It is asserted that masking paper now can be quickly peeled from a plastic piece after it has been soaked in a tank filled with the new compound. Marketed under the name of Turco Gummed Paper Remover, it is recommended for use with Plexiglas, Lucite, Plastacele, acetate, Pyralin and all transparent plastics.

★ A NEW INDUSTRIAL X-RAY UNIT DESIGNED FOR the inspection of parts, assemblies and finished products of plastics, hard rubber, ceramics, metal and dielectric materials has been brought out by the Industrial Electronics Div. of North American Philips Co., New York City. This machine is said to enable plant personnel to take satisfactory radiographs under controlled conditions and eliminate the expense of a skilled x-ray technician or a lead-lined room. Fixed milliamperage over the entire kilovoltage range makes the machine simple to operate. The fluoroscopic screen is mounted under a tunnel at the bottom of the radiographic compartment to permit the insertion or removal of the x-ray film without disturbing the object under inspection. A continuous kilovolt regular makes it possible to adjust for parts of varying thickness and density at any point from 0 to 150 kv. during the viewing operation.

★ IMPERIAL BRASS MFG. CO., CHICAGO, ILL., ANnounces the development of a new flaring tool for use with plastic tubing. This tool produces the approved type, double thickness flare for connecting tubing with flare fittings and is designed to handle tubings with outside diameters of $^3/_8$, $^1/_2$, $^5/_8$ and $^3/_4$ inches. Although especially suited for service on tubing with a .062-in. wall, it may also be used on tubing with a .031 in. wall. Flaring, bar, yoke with swivel cone and 4 adaptors are furnished.

★ LABELS FOR THE INDIVIDUAL MARKING OF aircraft replacement parts are offered by Avery Adhesives, Los Angeles, Calif. Mounted on translucent tape, the stickers may be easily marked with the desired code numbers on an Addressograph machine. The labels can be applied without moisture. It is asserted that they adhere firmly in spite of extreme heat, cold or humidity and can be quickly peeled off without injury to the surface of the parts.

★ A DRY MATERIALS BIN LEVEL INDICATOR OPERated on the electronic principle has been brought out recently by the Mosher Electronic Control Systems, New York, N. Y. The device consists of two parts: a detector box and a signal control box. The detector box contains a series of vacuum tubes and is attached to a probe extending into the bin. The



signal control box (left) is attached to colored lights which indicate whether the bin is full or partly filled. Hook-up with valve cut-offs, sound makers or remote signal devices can be arranged through a series of appropriate relays. The device is designed to measure material of varying degrees of fineness.

★ ELASTIC STOP NUT CORP. OF AMERICA, UNION, N. J., has acquired world rights to a new, lightweight, spring-lock fastener which is said to be particularly suited for use on the engine cowlings of high-speed war planes. The company states that the fastener has successfully met the specifications of the Army Air Forces and Navy Bureau of Aeronautics for use on military planes. The fastener also is said to be suitable for postwar applications including access plates on farm machinery, panels on motor trucks, home heating units and radio equipment

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Lower Pressures —The great plasticity obtained with electronic heat makes lower molding pressures possible than could be obtained with non-uniform heating.

Less Mold Stress —Easy flow of the plastic material decreases stresses on mold parts—especially in intricate molds—which means longer mold life, lower mold cost, and less danger of interrupting production due to damaged molds.

Improved Product —The low percentage of uncured resin obtained with electronic preheating makes for stronger products. The more uniform curing (or polymerization) of the plastic reduces residual stresses which cause warpage and distortion of the product. This means that better dimensional stability may be obtained.

Overall Time-Saving —The time-saving possible with electronic heat will vary with different applications. In general, a reasonable estimate is that two presses will do the work of three—an increase of 50%—when electronic preheating is used.

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This book has been compiled with a 2-fold aim: to give a thorough and comprehensive treatment of pictorial drawing from the standpoint of theory and to make this presentation of practical usefulness in the war industries. The text was especially prepared to meet an immediate need in Ordnance, ship building and aircraft where it was felt that although many men can sketch from models without a background of theory, the presentation would help beginners in speeding up the construction of correct and legible sketches. An adequate amount of carefully graded problem material has been included in the book in order to permit the instructor to plot a well-rounded course without monotonous repetition. F.B.S.

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The Chemical Formulary, Volume VI

by H. Bennett, Editor-in-Chief

Chemical Publishing Co., Inc., 26 Court St., Brooklyn, 1943

Price $6.00 **635 pages**

Thousands of new formulae applicable to more than 20 branches of industry are contained in this book. Particularly interesting to readers of this magazine will be the chapters on adhesives, coatings, and rubber, resins, plastics and waxes.

★ FOR THE BENEFIT OF ITS MEMBERSHIP, THE Society of the Plastics Industry has published a timely and practical pamphlet entitled "Job and Individual Merit Ratings." Based largely on an address delivered July 15, 1943, before the New York Chapter by C. J. Uhlir, head of Industrial Relations Department of National Metal Trades Association, this is one of a series of booklets the Society plans on various aspects of plant management and other matters affecting the maximum operating efficiency of plastics plants. The discussion considers the procedure for rating jobs, the mechanics of job rating, the correlation of job ratings and earnings, and various factors involved in rating individuals.

★ "ELECTRONICS IN INDUSTRY" IS THE TITLE OF A 44-page booklet recently issued by RCA Victor Division of Radio Corporation of America, Camden, N. J. This amply illustrated, non-technical description of a wide range of electronic devices and their uses holds particular value for manufacturers interested in possible applications of electronics to their own lines. The booklet includes a brief but adequate treatment of the use of electronic power in the manufacture of plastic-bonded plywood and in the preheating of plastic preforms.

★ PUBLICATION OF THE A.S.M.E. MECHANICAL Catalog and Directory for 1944 by the American Society of Mechanical Engineers marks the appearance of the thirty-third of these volumes. The book contains a compilation of catalogs arranged in alphabetical order, a directory of firms serving the field, an alphabetical list of trade names and a 16-page insert supplying information on A.S.M.E. codes, standards, periodicals and other publications. The products of approximately 400 manufacturers are classified and the market sources indicated for almost every item needed by mechanical engineers.

★ AS ITS TITLE IMPLIES, SWEET'S FILE FOR PRODuct Designers is a file of manufacturer's catalogs compiled especially for engineers and executives concerned with product development and design. The 5 sections into which the book is divided are: materials, finishes, parts, techniques, work equipment.

★ BARDWELL & McALISTER, INC., HOLLYWOOD, Calif., has announced the publication of 2 new booklets describing the Rosán locking system. Both these publications, the Standards catalog and the Design Data Sheets, explain the application of this locking system for threaded inserts and studs, and give full instructions for its use with all types of material. Engineering data for various diameter holes, counterbore sizes, etc., necessary in the installation of this system also are included.

★ THE FIRST 18-PAGE SECTION OF A NEW "LOOSE-Leaf" catalog dealing with many phases of hydraulics as applied to machine tools and aviation, has been released by Hydraulic Machinery, Inc., Dearborn, Mich. A preface is included which shows the company's facilities for the tooling and building of special machinery. Sections also are devoted to hydraulic power unit—one to hydraulic test benches, another to special machinery and one to presses. Of the semi loose-leaf type, it combines all the advantages of permanent and loose-leaf binding.

★ THE DIVISION OF LABOR STANDARDS, U. S. DEpartment of Labor, Washington, D. C., has issued a booklet on "Wartime Working Conditions" giving minimum working standards for maximum production. American industrial experience, both in World War I and to date in this war, is summarized. The pamphlet deals primarily with safeguards to the physical efficiency of workers. It also discusses technical problems of safety, health, sanitation and work hours.

★ PLASTICS INDUSTRIES TECHNICAL INSTITUTE, Chicago, Ill., has brought out a new catalog of its home study course, entitled "Build Your Future in the New World of Plastics." The first part of the 22-page, illustrated booklet reviews some of the outstanding military uses for plastics, forecasts coming developments and briefly surveys the careers in this field. The remainder of the prospectus is devoted to a description of the organization and facilities of the Institute and the curriculum.

★ ELMES ENGINEERING WORKS, CHICAGO, ILL., has issued a new bulletin called "Hydraulic Plastic Molding Presses" which describes the presses used for compression and transfer molding processes (hand-molding press, semi-automatic press and transfer molding press), their controls, power sources and construction. Cross-sectional diagrams of press operations are included in the pamphlet as well as photographs of the three types of press construction.

WASHINGTON ROUND-UP

R. L. VAN BOSKIRK, Washington Editor

Curtailment of plastics for marginal civilian uses

Many members of the plastics industry were considerably shocked when the Chemicals Bureau announced on Jan. 1 that plastic materials for marginal civilian end uses would have to be curtailed in the early months of 1944. The shock came because the situation looked good during the closing months of 1943—particularly in acetates and polystyrene, the very items in which the greatest curtailment is threatened for the next few months.

The WPB announcement declared: "The depletion of phthalate plasticizer stockpiles has necessitated conservation measures which will have a direct bearing on the availability of cellulose acetate and cellulose acetate butyrate. Instructions have gone out to material manufacturers that alternate: less-critical plasticizers must be used for materials for marginal civilian uses and that the formulations may not contain more than 10 percent phthalate plasticizer. Some delay in shipments for marginal uses probably will result until workable non-critical plasticizers can be adopted."

On the subject of polystyrene and phenolics WPB said: "Both of these plastics are directly dependent upon benzene as a basic raw material. War demands for benzene—chiefly for aviation gas and rubber—are far in excess of capacity production. Stockpile production requires immediate conservation measures, and many marginal civilian uses for both polystyrene and phenolics may be curtailed partially or completely. For the next 6 months applications for marginal uses will be scrutinized carefully from 3 standpoints: 1) efficient usage of the material, 2) essentiality of the product for civilian economy and 3) availability of alternate materials."

There are many factors behind this sudden dislocation of an industry which was beginning to show signs of good balance. First, the coal strike. Benzol (benzene), made from coal tar, is an important raw material used in the manufacture of phenol, polystyrene and plasticizers. When coal mining stopped, there was an appreciable drop in the production of benzol which carried on down through to some of the materials made from benzol. So far there is no indication that phenol production for use in military plastics has been definitely hindered by the temporary reduction in benzol production. But the amount of benzol used in the manufacture of polystyrene was definitely curtailed. Polystyrene was allowed 50 percent for combs and cosmetic containers in November but totally denied in December. The second work stoppage was a strike in the country's largest butyl alcohol plant. Several weeks' production were lost never to be recovered. The toll was taken from butyric acid which is used in cellulose acetate butyrate; dibutyl phthalate, an important plasticizer in acetate production; and in resin solutions which employ butanol as a solvent.

Fears that the December acetate and butyrate allocations might have to be altered were finally dissipated. Somehow enough material was scraped from the barrel, and all allocations were permitted to go through as granted. Even the material for buttons was allocated and delivered on the December interim allocation despite published reports that acetate button material was refused.

When butyl alcohol became short as a result of the strike, two particularly good plasticizers—dimethyl and diethyl obtained from phthalic anhydride—were diverted to be used in other chemical operations. This situation resulted in a shortage of dimethyl and diethyl phthalate and a curtailment of acetate molding powder production because of the plasticizer situation. Thus, even if there should be enough butyl alcohol to meet demands of plastics producers, the acetate situation remains difficult because of the plasticizer shortage. This situation may well result in a further curtailment of non-essential civilian products. Furthermore the shortage may continue for several months.

In a conclusion to its announcement, WPB asserted that allocations for urea formaldehyde molding compounds probably would continue as in the past for uses of a utilitarian nature and that there had been no significant changes in the availability of plastic materials other than those mentioned in their Jan. 1 report. However, they warned that all forecasts were based on current conditions and were subject to unforeseen fluctuations resulting from changes in raw material availability, man-power, production, breakdowns, strikes, container availability and transportation.

WPB Plastics Section realigned

Clinton "Pete" Rector took over as Chief of the WPB Plastics Section on Jan. 1 in succession to Frank Carman who resigned to become general manager of the Plastics Materials Manufacturers Association in Washington. Mr. Rector has been with the Plastics Section for a year and a half. Most of that time he was Chief of the Thermosetting Unit although he has also been serving as Deputy Chief of the Section since last October. Before coming to WPB, Mr. Rector had spent practically all his business life in the plastics industry.

Assistants to the Chief will be Grayson W. Wilcox and Ward Jackson. Mr. Wilcox has been senior man under Mr. Rector in the Thermosetting Unit in administering molders' affairs. As part of his duties as Chief Assistant, Mr. Wilcox will serve as overall administrator of the phenolic resin and urea orders. Ward Jackson is Chairman of the End Use Committee and liaison man between WPB and the Service Air Forces. He also will work with the various administrators on facilities, molding equipment and PD 1-A's.

Due to a different set of problems and a constantly decreasing number of employees, Units of the Plastics Section are to be rearranged to meet the new conditions. A new set of Units will be established along the broad divisions existing in the industry and the old, familiar Thermosetting and Thermoplastic Units will be discontinued. The Adhesives Unit, as in the past, will be under Nils Anderson as Chief. Harry F. Allison, Richard L. Shipley and Joseph L. Morningstar will continue as associates. In addition to plastic adhesives they also handle such items as animal glue, bone glue, casein, tapioca and other starches.

A new Molders and Laminators Unit has been organized with Walter Wagner as Chief. Since raw material problems have eased up, they have been superseded by man-power and administration problems that are common to all molders and laminators regardless of whether they are working with thermosetting or thermoplastic materials. The new unit will handle allocations of all molding materials, thermoplastic as well as thermosetting, molds and machinery without any notable deviation from methods that have been followed in the past. The only molding powder not to be handled by this Unit will be vinyl derivatives which will continue in the Vinyl Resins Unit.

Richard L. Foote will continue to specialize in laminates as a member of this Unit, but he probably will serve for a short time only. Mr. Foote is on loan from the industry, has served WPB longer than all but 2 or 3 others in the Plastics Section and is sorely needed by his home company. Joseph Tatnall will continue to handle vulcanized fibre, but he too is on loan from industry and will soon return to his home company. Sylvester Kaas will work on plastics used in textiles and probably on other

duties as yet unassigned. C. D. Kerr, formerly in the Thermoplastic Unit, had been slated to take the acetate molding powder assignment but has been called back into industry.

George Sollenberger, former Chief of the Thermoplastic Unit will be moved over to assume leadership of the Specialties Unit. His associates will be Allan Shephardsen, Garret Peters and John Adrian. Paul Kingsley, who formerly handled Thermosetting Specialties is leaving WPB to join the office of Scientific Research and Developments. The Specialties Unit will be concerned with thermoplastic and thermosetting materials that are not of a molding power or laminating nature. This field includes the granular polymers, monomers, solutions, emulsions, sheets, rods, tubes and flake forms of cellulose acetate butyrate, nitro cellulose plastics, ethyl cellulose, cellophane polystyrene, acrylates and methacrylates, coumarone-indene resins, terpene resins, cast phenolics, allyl resins and specialty materials (phenolic, urea and melamine) used for brake linings, grinding wheels, impregnation, etc.

Garret Peters, a new man in the Plastics Section, comes from the Protective Coatings Section of WPB where he was a specialist on ethyl cellulose and nitro cellulose.

The Vinyl Resins Unit will continue under Robert P. Kenney and will handle the so-called elastomeric plastics including polyethylene and silicon resins. This Unit deals closely with problems of the rubber industry in wire and cable, coated fabric and shoe fields and also passes on essentiality of extrusion equipment. Mr. Kenney's associates will continue to be R. C. Martin and Will S. Thompson in addition to L. P. Hohfelder who previously had been specializing on synthetic raw materials and plastics machinery in the Chief's office.

Possible changes in M-154 and cellulose plastics order

Practically everybody in the industry knows by this time that WPB is preparing to make changes in Limitation Order M-154 (thermoplastic products) and in the cellulose plastics allocation order. How soon the changes may come is a moot question, but until that time the industry will have to work under provisions of M-154 and no stones will be left unturned to see that it is properly enforced.

We are led to believe that M-154 will not be technically revoked because there is no other way to control cellulose nitrate plastics. The order probably will be kept on the books for that purpose. However, ethyl cellulose, cellulose acetate, cellulose acetate butyrate, polystyrene and methacrylate doubtless will be removed from the order. Removing them from M-154 does not mean that they are in plentiful supply, but as each is under allocation, their end use will be controlled by the existing allocation orders. Furthermore there is not enough man-power in the Plastics Division to handle all the paper work involved in the voluminous appeals that come in under the provisions of M-154.

The bulk of the cellulose nitrate production goes into protective coatings, film and gunpowder. Whatever is used for plastics must be carefully accounted for. The reason that M-154 probably will be retained for cellulose nitrate plastics is because its existence can be used to prove to other WPB agencies that its end use pattern is above the unessential level in spite of the fact that the material is not on direct allocation.

In the meantime serious thought is being given to changing the acetate plastics allocation order. It is presumed that rods, sheets and tubes will continue to be handled as at present, but the revised order will likely provide for a method of allocating acetate molding powders by the same method now in use for phenolic and urea molding powders. Under that method the molder applies directly to WPB for authorization to accept delivery and use material for a specific end use. At the present time he applies directly to the supplier and the supplier bulks his end uses as reported by his customers when he requests his allocation. Under the revised order the molder will apply for his allocation on form WPB 2945 (the old PD-600) and his supplier will apply on WPB 2946 (the old PD-601) direct to WPB. Reason for making these changes is that the PD-600 and PD-601 method gives better control of end uses. If end uses are in tight control there is less need for Limitation Order M-154.

Price order for laminates still held up

OPA's price regulation for plastic thermosetting laminated materials has been in the hands of OPA lawyers since Nov. 13. It is not believed that they are tinkering with it, but they simply haven't put it through the mill. It is not anticipated that the new order will make any great stir among laminators. It was submitted to the Industry Advisory Committee and their approval was given. The order was forwarded to the OPA legal department promptly upon receipt of the Committee approval. A 10 percent cut was voluntarily taken last August, and the new order simply legalizes that price and allows the industry to continue its present pricing methods.

The only item in the order which it seems might arouse some feeling is that it will include laminated sheet material .050 in. and under. This thin material was not included in the voluntary agreement but will come under the terms of the new order. About half of the industry is selling its thin sheets at the list price which was in effect in January 1941, and the other half is selling at the list price prevalent before last August. Most operators have given a discount on this list price but not the full 10 percent given on all other laminated materials.

Check up on your shipping containers

If button molders have overlooked Order L-317,Oct. 11, 1943 (Fibre Shipping Containers), they had better start checking up on their box situation. That order limits the use of shipping containers to what amounts to 80 percent of the amount used in 1942. Not only are buttons on the restricted list but also combs and buckles. Furthermore there is a 65 percent limitation for such things as games and toys and plastic ornaments.

The restrictions do not apply to the Armed Forces, Merchant Marine or Lend-Lease except post exchanges or ships service departments within the 48 states and District of Columbia. There is no limitation, however, on re-used containers.

Vinyl resin shoe sole material in heavy demand

On Dec. 31 WPB wired to manufacturers of vinyl resins who had asked allocations for shoe soles, asking them to advise WPB by Jan. 10 what portion of their January requests for vinyl resin will be used for rationed shoe soles. This measure was deemed necessary because of the critical sole leather situation and the necessity for using considerable quantities of vinyl resins in the manufacture of shoes during 1944. In order to conserve all possible quantities of prime and off-grade vinyl resins, it will be necessary for the WPB to immediately limit the use of these resins to rationed shoes insofar as possible.

WPB officials asked the manufacturers to provide this supplementary information on the exact amount of their requests which would be used on rationed shoe soles. Unclassified requests for vinyl to be used in shoe soles will be considered as material for unrationed shoes.

A report on government standards for these shoe soles is expected soon. When that report is made by combined representatives of the Bureau of Standards, Office of Civilian Requirements and Plastics Division of WPB, it is hoped and believed that the problems incidental to various vinyl shoe sole materials and grades, will be eliminated.

New chemicals price executive

William L. Sims II has succeeded Joseph D. Coppock as Price Executive for the Chemicals and Drugs Price Branch of OPA. His duties will include supervision of resins and plastics. Mr. Sims formerly was Continental European manager for Colgate-Palmolive-Peet and has been with OPA as a consultant since last November. His jurisdiction does not include finished plastic materials which are administered in the OPA Machinery Branch.

NEWS OF THE INDUSTRY

★ A WAR PRODUCTION CONFERENCE, SPONSORED by Engineering Societies Committee on War Production at the request of WPB, was held on Jan. 14 at the Hotel Commodore, New York. The Chemical Industries Panel, under the auspices of New York Section of American Institute of Chemical Engineers, dealt with "Types of Plastics, Their Engineering Properties and Their Uses." Dr. Joseph Mattiello, vice-president and chemical director, Hilo Varnish Corp., served as chairman while Emerson J. Lyons, chemical engineer, Turbo Mixer Corp., acted as secretary. Dr. Robert J. Moore, manager, Development Laboratories, Resin Dept., Bakelite Corp., delivered the introductory speech on "Synthetic Resin Plastics." "Testing and Comparison of Molding Materials" was the subject of a talk by Robert Burns, Bell Telephone Laboratories. A question and answer period followed these talks.

CHARLES HAMILTON

★ CHARLES HAMILTON OF KURZ-KASCH CO., HAS been appointed president of Detroit Section, Society of Plastics Engineers. Other elected officers are vice-president, Gunnar Lindh, Udylite Corp.; secretary-treasurer, L. J. Morrison, Quarnsten Tool Co.; Members of the Board of Directors include: Bart Batty, Hercules Powder Co.; John Salter, Tennessee Eastman Corp.; Charles Hamilton; Fred C. Conley, Chicago Molded Products Co.; George Gress, Monsanto Chemical Co.; William B. Hoey, Bakelite Corp.; Carl Sundberg, Sundberg and Ferar; Gunnar Lindh; and L. J. Morrison.

At a meeting of the Cleveland Section of S.P.E. held on Dec. 17, C. D. Shaw led a round table discussion of various methods of injection molding thermosetting materials and announced a new process called "flow molding" which was invented by L. S. Shaw.

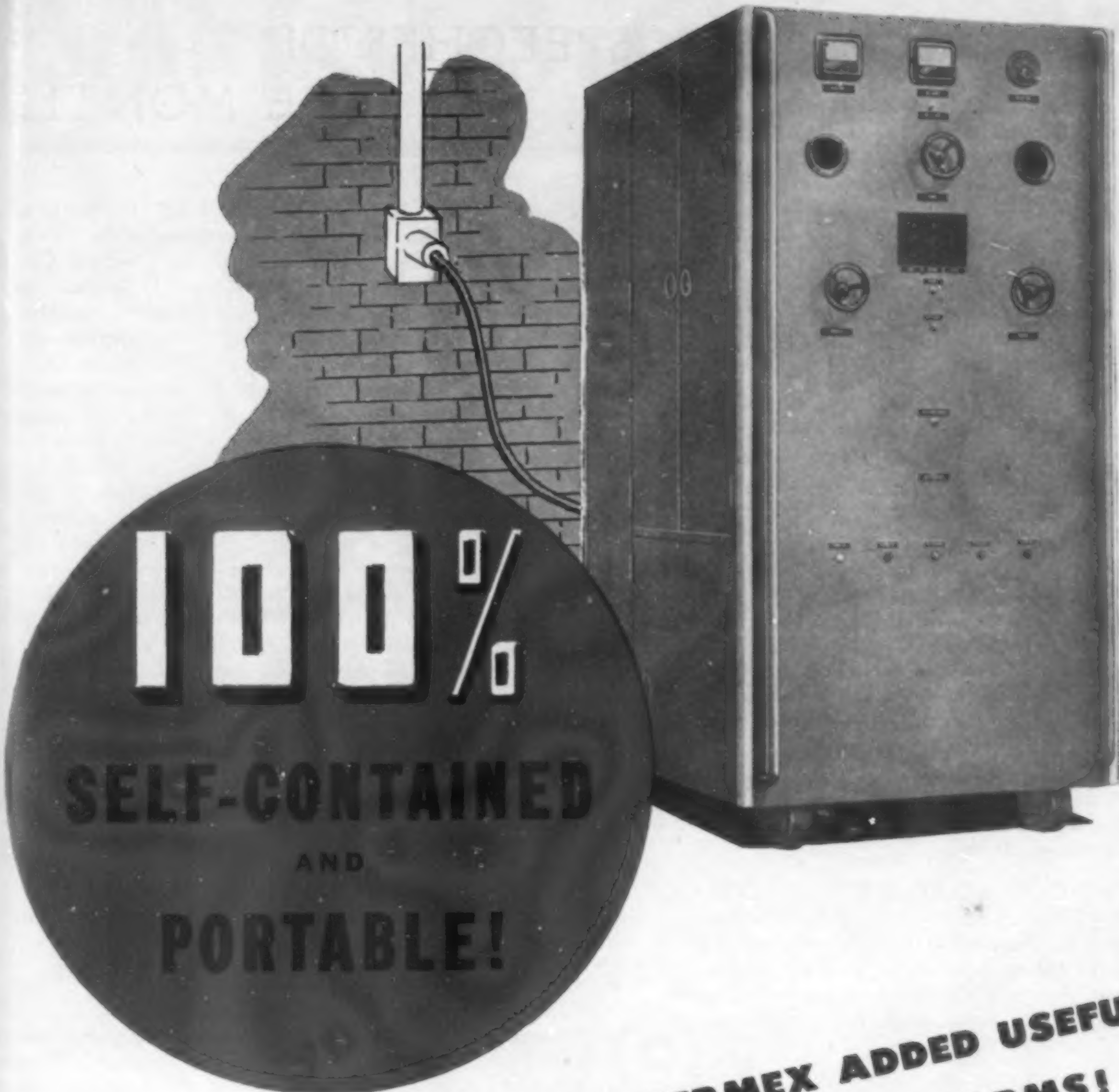
At a meeting of the Chicago chapter of the Society of Plastics Engineers held Jan. 4 at the Merchant's and Manufacturer's Club announcement was made of newly elected officers and board members of both the national organization and the Chicago chapter. Charles Henry, of Chicago Die Mold Co., was elected president of the national board of directors and Winfield T. Cooper, Chicago manager of Bakelite Corp., president of the Chicago chapter. Other national officers are: William B. Hoey, vice-president; George C. Gress, secretary and treasurer. The national board of directors includes: George Clark, Plastics Research, Owens-Illinois Co.; William Goggin, Dow Chemical Co.; Robert H. Morehouse, Cardinal Corp.; N. J. Rakis, plastics engineer, Chrysler Corp.; John A. Mickey, plastics engineer, Ford Motor Co. L. H. Amerine of Imperial Molded Products was elected vice-president of the Chicago chapter; Jack Porte of Monsanto Chemical Co., secretary-treasurer. The Chicago board of directors includes: W. Ellison, Richardson Co.; Lee T. Bordner, Eclipse Molded Products; Charles C. Henry; L. W. Anderson, Chicago Molded Products; L. H. Amerine; J. O. Reinicke, Barnes and Reinicke; Winfield T. Cooper; A. W. Nelson, Rada Products Co.; and Jack Porte.

★ PLANS FOR THE SECOND ANNUAL CONFERENCE of the Pacific Coast Chapter of Society of the Plastics Industry to be held on Monday and Tuesday, Feb. 21 and 22, at the Ambassador Hotel, Los Angeles, Calif., now are about complete. The Monday morning session will be devoted to a general summary of the plastics industry in California. "Recent Developments in Plastics Materials" is the topic to be covered during the afternoon meeting. The subject for Tuesday morning will be "Plastics Applications in Aircraft," and the afternoon will be devoted to a round table discussion of postwar activities. A special feature will be displays of plastics parts and products arranged by Clark Richards, Jr. Exhibit space is free and information can be obtained by writing to Mr. Richards at 605 W. Olympic Blvd., Los Angeles. Requests for hotel reservations should be directed to Frank Wilcox, Society of Plastics Industry, 971 Goodrich Blvd., Los Angeles 22.

★ AT THE DINNER MEETING OF THE NEW YORK chapter of the Society of the Plastics Industry held Jan. 20 at the Yale Club, New York City, the following speeches were delivered: "The Design and Merchandising of Proprietary Plastic Items," by R. H. Cunningham, manager, Engineering and Sales Dept., Hemco Plastics Div., Bryant Electric Co.; "Diamond Tools, Some Applications to Plastics Finishing," by S. G. Warner, president, Staset Co., Inc.

The annual meeting of the Canadian section of the Society which was held on Jan. 25 at the Royal York Hotel, Toronto featured a special conference of the plastics industry in Canada. A large display of molded plastic products drawn principally from the membership of the Canadian section was augmented by a selection of plastic applications which originally appeared in the MODERN PLASTICS exhibit. James Neal, president, Norton Laboratories, Inc., Lockport, N. Y., the luncheon speaker, took as his subject, "Twenty Years a Molder." B. K. Sandwell, editor of *Saturday Night*, one of Canada's most influential weekly newspapers, was the guest speaker at the banquet. During the morning and afternoon sessions the following papers were presented: "Vinyls," by G. Shaw, Union Carbide and Chemical Co.; "Plastics from Wood and for Wood Improvement," by R. V. V. Nicholls, McGill University; "Mosquito—a Design in Wood," by R. B. McIntyre, project engineer, De-Havilland Aircraft Co. of Canada, Ltd.; "Melamine Resins—Their Properties and Applications," by C. J. Romieux, sales manager, Plastics Div., American Cyanamid Co.; "Development of Post-War Plastic Products," by Morris Sanders, architect and industrial designer; "Metal Plating Plastics," by R. R Dickey, manager, Plastics Div., Monroe Auto Equipment Co.; and also a paper (speaker unlisted) on the latest advances in electronic heating of plastics, by RCA Victor Company.

★ AT THE CHRISTMAS GET-TOGETHER AND DINNER of the Detroit Rubber and Plastics Group, Inc., Detroit, Mich., Prof. C. W. Selheimer reported on the progress of the rubber and plastics laboratory of the Chemical Engineering Dept. at Wayne University. One-third of the necessary funds for the equipment of this laboratory, which has been a major interest of the group for the past 2 years, now are in hand. This month a course in the chemistry of rubber and plastics will become part of the regular chemical engineering curriculum of the University.



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★ FURTHER EXPANSION INTO THE PLASTIC FIELD was marked by Libbey-Owens-Ford Glass Co.'s recent acquisition of Paramet Chemical Corporation. A wholly owned subsidiary, known as Paramet Corp., and formed by the glass concern, purchased the physical assets, patents and good will of Paramet Chemical Corp., Long Island City, N. Y. Early last year, Libbey-Owens-Ford Glass Co., also acquired Plaskon Co., as a subsidiary. Paramet, while maintaining autonomy so far as possible, will operate as an adjunct of the Plaskon division. Officers of the new corporation are: James L. Rodgers, Jr., president; Bernard W. Slaer, vice-president and general manager; C. Homer Flynn, vice-president and sales manager; W. R. Feldtman, treasurer; and C. O. Marshall, secretary. Paramet manufactures ester gums, alkyd, phenolic, modified phenolic resins.

★ DR. R. MAX GOEPP, JR., HAS BEEN APPOINTED director of Organic Research, Industrial Chemical Department, Atlas Powder Co., Wilmington, Del. Dr. Goepp's work has been mainly in the field of carbohydrate chemistry, and he is a past chairman of the Sugar Division of American Chemical Society.

★ CALCO CHEMICAL DIVISION, AMERICAN CYANAMID Co., has announced the purchase from Interchemical Corp. of its United Color and Pigment Co. Division, Newark, N. J., which produces organic and inorganic chemical colors. Since many of the organic intermediates and dyes manufactured by Calco Chemical Division are used in the production of organic chemical colors, it is anticipated that the combined production, research and technical facilities of the 2 plants will make possible greater contributions to the pigment-consuming industries. The new unit will be known as United Color and Pigment Dept., Calco Chemical Division. No changes of management, personnel or policies are contemplated.

★ MODERN PLASTICS TRAVELING EXHIBIT WILL have a showing in New Haven, Conn., on Feb. 12 to 19, inclusive, under the sponsorship of the New Haven Chamber of Commerce. During March the exhibit will be at Sears Roebuck department store in Chicago, Ill. Throughout April the show will remain in Oklahoma City, Okla., under the sponsorship of the Oklahoma City Chamber of Commerce.

★ AT A RECENT MEETING OF THE BOARD OF DIrectors of Joseph Stokes Rubber Co., Trenton, N. J., Walter E. Harvey was elected vice-president and R. H. Temple was made secretary. Mr. Harvey and Mr. Temple also are vice-president and secretary-treasurer, respectively, of Thermoid Co., Trenton, which recently acquired Joseph Stokes Rubber Co.

★ THE PERSONNEL OF THE DOW CHEMICAL CO.'S new Philadelphia and New England sales offices which were opened Jan. 3, 1944, has been announced by Clayton S. Shoemaker, Eastern sales manager. The Philadelphia office will be headed by Alexander Leith, Jr., who has been with Dow's New York sales office since 1923. Other members of Dow's Philadelphia office will be: Frank H. Sellars, 3rd, magnesium sales; Elmer K. Stilbert, plastics engineering; and Charles E. Seel, heavy chemicals and pharmaceutical sales. Alfred A. Lawrence, who has been with Dow since 1940, will manage the New England sales office in Boston, Mass. This staff also will include Felix J. DeSantie, heavy chemicals and pharmaceuticals; George B. Makepeace, plastics engineering; and Bradford Durfee.

★ P. B. LEVERETTE HAS JOINED PARKWOOD CORP., Wakefield, Mass, as vice-president in charge of engineering and development. For the past 13 years Mr. Leverette has been associated with Plastics Divisions, General Electric Co.

★ EXECUTIVE COMMITTEE OF AMERICAN SOCIETY for Testing Materials, Philadelphia, Pa., has decided to hold the 1944 Spring Meeting and Committee Week at Netherland Plaza, Cincinnati, Ohio, on Feb. 28 to March 3. A symposium on application and uses of synthetic rubber will be the technical feature of the meeting. *(Please turn to page 186)*

SPEECHES OF THE MONTH

★ IN AN ADDRESS DELIVERED JAN. 5 AT THE HOTEL Commodore, New York, Gaston DuBois, recipient of the Perkin medal and senior vice-president of Monsanto Chemical Co., urged more active participation by scientific men in the guidance of government research and manufacturing facilities. Speaking on the occasion of the award of the medal by the American section of the Society of Chemical Industry, Dr. Dubois specifically recommended the establishment of a competent committee of representatives of the scientific and manufacturing fields with the purpose of outlining constructive suggestions on policy, scope and budgets. He particularly emphasized the present responsibilities of the chemists with respect to our patent system and said that the changes proposed in the system in the report of the National Patent Planning Commission are as important to the chemist as to the business man or lawyer. He also raised the question of the advisability of peacetime government control of the manufacture of nitrates, ammonia, styrene, butadiene, carbide, synthetic rubber, phosphorus and fertilizers. Stressing the phenomenal growth of the American chemical industry since World War I, he concluded that as science becomes increasingly important to civilization and the chemist steps out of his laboratory to engage in new activities related to the widening scope of his industry, he must accept the responsibilities consistent with his new status.

★ IN A TALK ON "THE SELLING APPEAL OF PLAStics" given before the Plastics Club of the United States in New York City on Dec. 14, John K. Honish of Bakelite Corp., discussed the intrinsic utility values of various plastic materials with especial emphasis on their sales-stimulating features

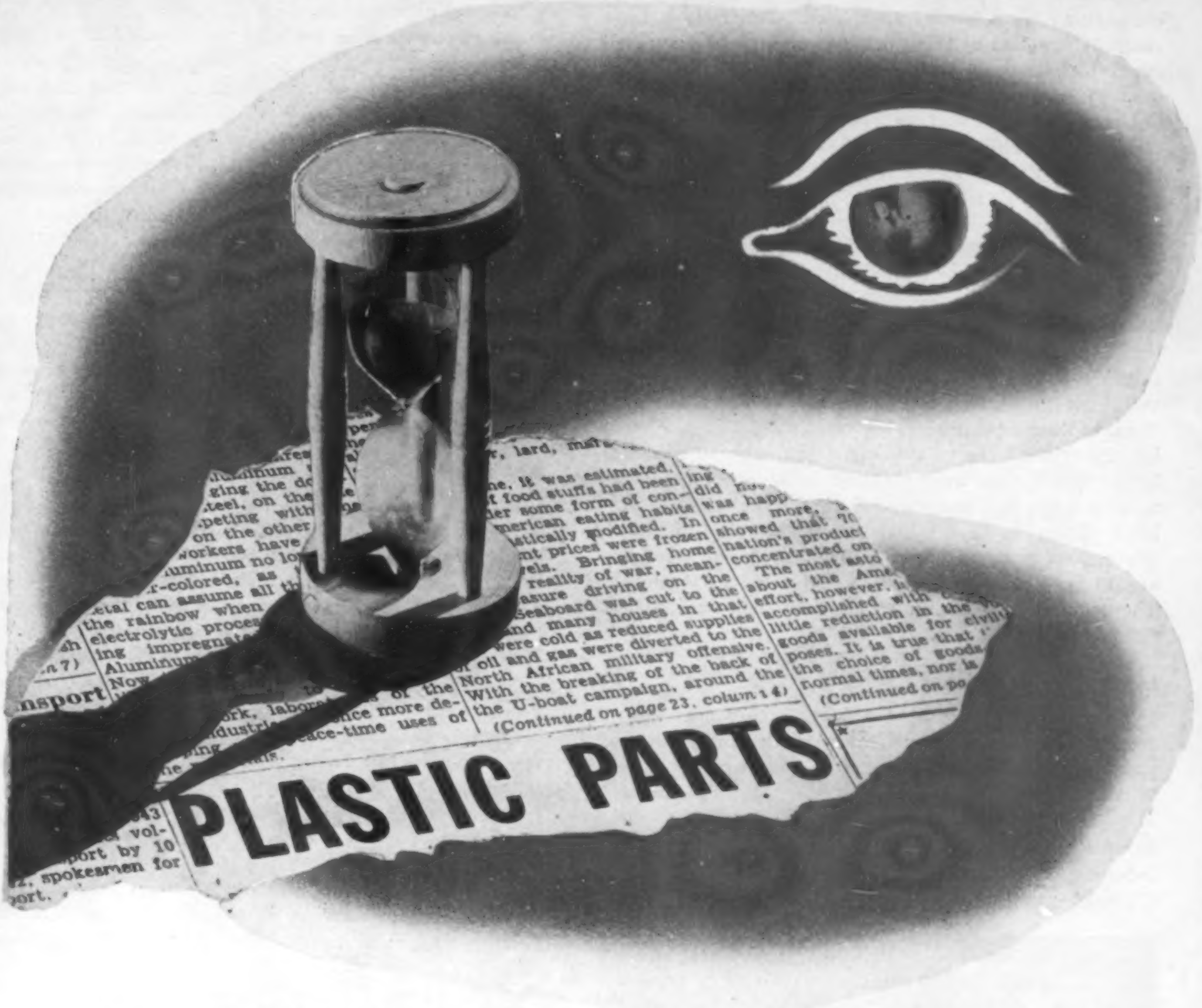
★ "INJECTION MOLDING AND MOLD DESIGN" WAS the subject of a talk delivered by Islyn Thomas of Ideal Plastics Corp., on Jan. 17 at a meeting of the Plastics Engineers Association held at the Yale Club, New York. The speaker surveyed the history of injection molding, considered the question of mold design and covered a number of problems encountered in injection molding and their solution. N. G. Levien of Ivorycraft Co. addressed the members on "New Horizons in Plastics," taking as his theme some of the more spectacular wartime accomplishments of plastics manufacturers.

★ ROY BERG OF TECH-ART PLASTICS CO. SPEAKING before the Plastics Institute Alumni Association on Jan. 12 at the Pennsylvania Hotel, New York, chose as his topic: "Plastics—Their Applications and Factors in Selecting the Proper Plastics for the Job." Mr. Berg discussed the properties of the various plastics and the selection and application of plastic materials in accordance with their individual uses.

★ NYLON AS A MOLDED PLASTIC WILL DEVELOP vastly expanded uses in the postwar era, Dr. Russell B. Akin of E. I. du Pont de Nemours and Co., Inc., reported in a speech delivered before the Society of Plastics Engineers on Jan. 5. Devoting his discussion chiefly to the properties and uses for FM-1 molding powder, he explained that this material is distinguished for its toughness, high softening temperature and the facility with which it may be injected into thin sections around complicated inserts.

★ ON JAN. 4 AND JAN. 5 MORRIS SANDERS, WELL-known industrial designer and industrial plastics design advisor to the Celanese Celluloid Corp., New York, spoke over Station WJZ and the Blue Network, respectively, on "Plastics in the Postwar Home." Harriet Raymond, advertising manager of the same company, delivered a talk on Jan. 7 over Station WQXR on "Plastics for Everybody."

LOOKING INTO THE FUTURE



PLASTICS MAKE NEW WORLD

In a world at war, plastics have played a vital part in replacing critical metals and in saving priceless production time. In a world at peace, plastics will play an even more important part in bringing comforts and conveniences to millions of homes. In such fields as electronics, air conditioning, transportation, plastics are virtually essential. In the manufacture of thousands of products, plastic parts will save production time, decrease costs, and improve their appearance. The knowledge which our organization has gained in molding wartime products is available to manufacturers with peace-time plans.

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A new gluing process

(*Continued from page 129*) much greater heat losses are encountered in the slower assemblies. This ratio is more generally found to be about 6:1 in practice and may even rise to 10:1 where the time of gluing is unusually long, e.g., over 20 minutes.

The resistivity of acetylene black decreases with rise in temperature. This means an accelerated rate of heating of the glue line at higher temperatues, but partial compensation for this is obtained in higher heat losses to the surrounding wood. Figure 5 (curve 1 at 220 volts; curve 2 at 110 volts) shows the general relation between temperature in the glue line and the product of the current being drawn and the total time of gluing up to that point. These linear relations again are compilations from various test data and are not necessarily comparable with other relations shown elsewhere. It should be noted that, at a constant voltage, it is a measure of the work done, and this is proportional to the temperature. The rate at which energy is put into the system in curve 1 is double that of curve 2 on this basis. These data were obtained in several experiments using multiple glue line assemblies and a brush coated glue-black dispersion. The initial amperages for a 9 in. width (direction of current flow) and a 10 in. length were as follows: at 110 volts, 0.80 amp. and at 220 volts, 1.55 amperes. The final amperages were: at 110 volts, 1.45 amp., and at 220 volts, 3.1 amperes.

Electrodes

The electrodes generally used have been copper wire of about 23 gage. It is apparent that the diameter used must be sufficient in view of the anticipated current to be drawn. The diameter of the wire also must be

6—Multiple laminated wood is being assembled in a laboratory hydraulic press which has 14 x 14 in. platens. The glue lines have been arranged in parallel

such as to show no appreciable voltage drop along the electrode. If such voltage drop is obtained, it must be obviated either through the use of a heavier wire or by feeding in the potential at more than one point in each wire.

The electrodes were generally laid parallel to the edge of the wood and about $^1/_8$ in. in from the edge. The wire was stapled down over the edge of the wood at each end. It is apparent that other types of electrodes also may be used, including metal ribbon and bar contacts of various types outside of the work. It is particularly important to note that metal wire is readily buried in the wood when placed parallel to the grain. This is readily accomplished therefore in both laminated wood and plywood.

Figure 6 shows battery clips attached to the ends of the electrodes in the glue lines of an experimental assembly. The electrodes may be permitted to remain in the assembly, or the outside edges may be trimmed off, and the wires re-used indefinitely. In the case of fabric mesh carrier, electrical contact through the carrier should be between wood surfaces only, and not in a position exposed to air.

Pressure

The pressure required in conjunction with this process is the normal pressure commonly used with the wood species being glued, i.e., from 150 to 300 pounds per square inch. Pressure is applied in any convenient manner, e.g., by clamps, jigs, hydraulic press, screw press or hydraulic hose press. Figure 6 shows a photograph of an experimental assembly in a small laboratory hydraulic press. The multiple glue lines are shown in parallel. The laminae ($^3/_4$ in. birch) are 9 in. in width and 10 in. in length.

An interesting relation was found between current and pressure, as shown in Fig. 7. Curve 1 shows results obtained in a lamination with multiple glue lines using a brush-coated dispersion of black in resin glue. The question of temperature was not involved since the current flowed for only very brief periods. The initial reading was about 1.2 amp., which rose steadily to about 2 amp. at 450 pounds per square inch. On allowing the pressure to decrease to 150 p.s.i, this increased conductivity was virtually fully maintained. On reverting to the higher pressure, the conductivity increased to about 2.65 amp., and this conductivity was then maintained on release to a lower pressure. Further cycles brought about little change. The effect obtained is probably two-fold, viz., 1) a packing effect, bringing the particles of carbon in closer contact, and 2) a smoothing out of the ridges left by the brushing, which adds further paths and therefore current carrying capacity.

Curve 2 shows the relation between current and pressure for acetylene black on a conductive fabric mesh carrier. It is noted that increase in pressure has no appreciable effect on the conductivity. It is apparent that the black is held in place by the binder and is also already well oriented on the fibers of the fabric.

Temperature and moisture content of wood

Using this process, glue lines have been heated to over 300° F. It is obviously of interest to know how quickly this heat escapes and what temperature is reached by the wood. Heating by high frequency involves considerable direct heating of the wood. Using the present method, the wood is heated only by thermal transfer from the glue line. This type of loss is readily calculable. Some actual experimental data are, however, of interest.

Figure 8 shows the temperature of the wood at various

distances from a heated glue line during the heating period. The temperatures were measured by copper-constantan thermocouples, inserted at the center of the assembly and attached to a calibrated potentiometer, using an external cold junction. Conductive fabric was used in all experiments. Curve 1 in each series represents the heating curve for the glue line itself and curves 2, 3, 4 and 5 are corresponding heating curves for positions in the wood 0.05, 0.2, 0.25 and 0.5 in. distant from the heated glue line, respectively. The two sets of curves are for 110 and 220 volts, and the time ratio is here about 6:1. The assembly had a total thickness of 4.5 in., and one glue line only, half-way through the thickness, was heated. It is noted that at a distance of 0.5 in. from the glue line being heated, the temperature of the wood has reached only about 90° F. when the glue line has reached 300° F. When the assembly is removed from the press the temperature near the outside begins to rise as heat is lost from the glue lines.

The moisture loss from laminated wood assembled by this process was measured repeatedly, using an electric moisture meter. The changes noted, after heating glue lines to 300° F. and allowing the laminates to cool, were on the average less than 0.5 percent and were considered negligible. The moisture content of the wood being glued plays the usual role, except that consideration must be given to the fact that, with this process, moisture is being driven away from the glue line. In general we have found a very wide range of moisture content suitable for the purpose. It is of particular importance to note that variations in moisture content of adjacent layers of wood are of no consequence in the employment of this process to produce uniform heating of glue lines.

Equipment, power requirements and efficiency

The equipment needed for this gluing process is virtually negligible. A circuit leading to bus bars in proximity to the work, accompanying switches and meters, complete the list. It is obviously not possible to read the temperatures reached in glue lines in production by means of thermocouples. The end-point can be calculated readily on the basis of the work done or $I \times t$ at a given voltage, and, therefore, the indicator may be either a watt meter or an ammeter in conjunction with a stop-watch. The efficiency of the process is obviously 100 percent. It is of interest to give one average figure which we have observed by way of power requirements; viz., 0.4 watt-hr. per sq. in. of glue line area, to an end-point of 250° F.

Some attention has been devoted to various types of regulators designed to ensure uniform heating in various glue lines, but further work has shown this to be generally unnecessary. The margin of leeway allowable between slowest and fastest heating glue line is so large as to exceed differentials actually obtained in all cases. Some form of simple control might be found desirable in operation on an industrial scale.

Quality of glue line

Particular attention has been paid throughout the course of this development to the quality of the glue line. The resin glue itself may, of course, be expected to yield normal results. There are two factors which are somewhat different and which might have an effect on quality, viz., 1) heat is applied at the glue line and there is therefore a

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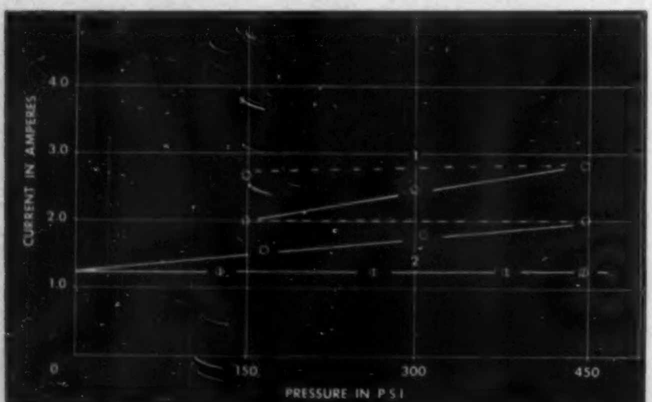

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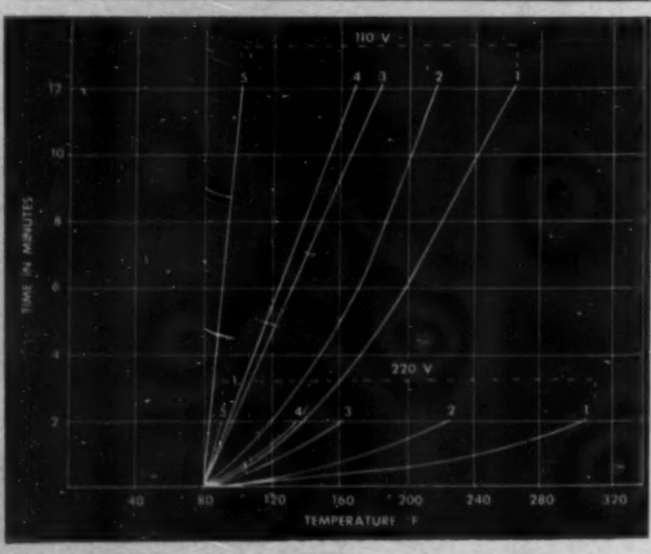

7—Graph of the effect of increasing and decreasing pressure on conductivity. (1) indicates glue-black dispersion coating; (2) fabric mesh carrier for the black. **8**—*Graph of rate of heat loss into the wood from a glue line heated by resistance heating. Two series are shown for 110 volts and 220 volts. In each series (1) is for glue line; (2, 3, 4 and 5) are heating curves for positions in the wood 0.05, 0.2, 0.25 and 0.5 in. from glue line respectively. Fabric mesh carrier for black is used in both series.* **9**—*An illustration of wood failure obtained in standard shear test specimens and on breaking into the glue lines of larger area*

9

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tendency to drive moisture away from the glue line, and 2) the presence of the conductive black.

Qualitative knife tests showed uniformly excellent results. Wood failures were very high, and it was difficult to force a chisel to follow the glue line. Figure 9 shows photographs of several such breaks. A number of shear tests were carried out on various assemblies[13] and the results showed that the shear strengths and wood failures were very good in all cases where the experimental factors were maintained correct as shown in the preceding sections. Undercure must, of course, be avoided, and it is important to note that the so-called intermediate-temperature resins were found to cure in some instances rather more slowly than understood from manufacturer's instructions. The fact that in this process the moisture is being driven away from the glue line indicates the use of resins which have a reasonably good flow prior to cure. Shear strengths at least equal to that of the wood itself and wood failures close to or equal to 100 percent were found readily attainable, when due regard was paid to these factors.

Larger scale trials

A number of experiments were conducted at an aircraft propeller plant[14] where various multiple glue lines were assembled. The assemblies were in general about 8 ft. in length, 10 in. wide and consisted of from 6 to 9 laminae of $^3/_4$ in. birch. Some experiments were carried out also with Douglas Fir. Trials included variation in voltage, glues and other factors, and many useful data were obtained. The method appeared in these trials to show excellent promise for large scale use. It was found that propeller blanks could be glued in as short a time as 2 min. using a hot setting glue, and such blanks could be placed into production immediately. This compares with a press time of 6 hr. and a conditioning period of 7 days in the normal process using cold setting urea resin.

Various applications

The above description has been concerned almost entirely with thick sections of laminated wood and, as was earlier indicated, this class of work is considered the most direct application for this novel process. As examples, might be mentioned propellers and spars in aircraft, keels and framing members in ships, engineering booms, trestles, laminated arches and trusses, and laminated timbers of various types.

Plywood is conveniently and efficiently produced with conventional hot plate presses. The present method might find application to plywood in that conductive carriers, fabric or paper, could be introduced between plywood assemblies to act essentially as extra "hot plates" or sources of heat. Conductive paper for example could be manufactured very cheaply and could, if desired, be considered expendable. Thus a very large number of assemblies could be glued up simultaneously. Such a procedure would appear to offer many advantages for practical use.

High-density plywood or laminated wood, known as compreg, has attained considerable importance in certain applications. The compreg must be manufactured in relatively thin layers, e.g., 0.5 in., because of heat transfer considerations. The bonding of such compreg boards then offers the same difficulties as those discussed for laminated wood. The gluing of layers of compreg can be effected by this novel process, using any resin adhesive which is suitable for the work. One point of difference arises in that the electrodes cannot be buried in the compreg. The wires therefore must be inserted in grooves machined for the purpose or other types of contacts must be brought in from outside the work. The bonding of high-density to normal wood entails no change from ordinary laminated wood.

An application of some interest is the lamination of resin-impregnated fabric to thick sections. The cure of the resin in such instances requires many hours in a hot press with consequent danger of over-cure on the outside. Preliminary experiments on a laboratory scale have shown that a fabric can be readily impregnated with a laminating varnish containing acetylene black. Stacks of these sheets were then laid up with metal sheets at top and bottom. A section of such a fabric laminate, 6 in. thick, was cured within a few minutes at a temperature of 300° F. It is to be noted that such an assembly is permanently conductive after manufacture. Figure 10 shows an assembly of this type being cured on a laboratory scale.

Summary of advantages of new process

1. Hot-setting procedure is used in a cold press.
2. Assemblies of any dimensions can be manufactured, with limitations in the width at low voltages.
3. Pre-manufactured film glues may be used.
4. Simple equipment only is required.
5. The method does not require the development of a special technique in use.
6. The method can be used anywhere near a source of electric power of ordinary characteristics.
7. Heat is applied directly where required, viz., to the glue line.
8. The method is very rapid.
9. The heating is readily controlled.
10. The brief time required is independent of the dimensions of the assembly.
11. The process is very cheap in operation.
12. Curvatures are obtainable.
13. Variations in the moisture content of the wood layers are of little consequence.
14. Glue lines set up by this procedure show excellent quality in wood failure and shear strength.

[13] The cooperation of the Forest Products Laboratories of the Department of Mines and Resources, Canada, in this testing, is gratefully acknowledged.
[14] S & S Aircraft Ltd., Canada.

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10—*Laboratory scale of the assembly of a fabric laminate, 6 in. thick, being cured by resistance heating*

Creep properties

(*Continued from page 144*) may be seen that a change in any of the resistances R_{2c}, R_{2L}, R_{1L}, R_{1c} or R_d, or in the thermal potentials, E_{T1} or E_{T2} may also require a new micrometer or decade reading.

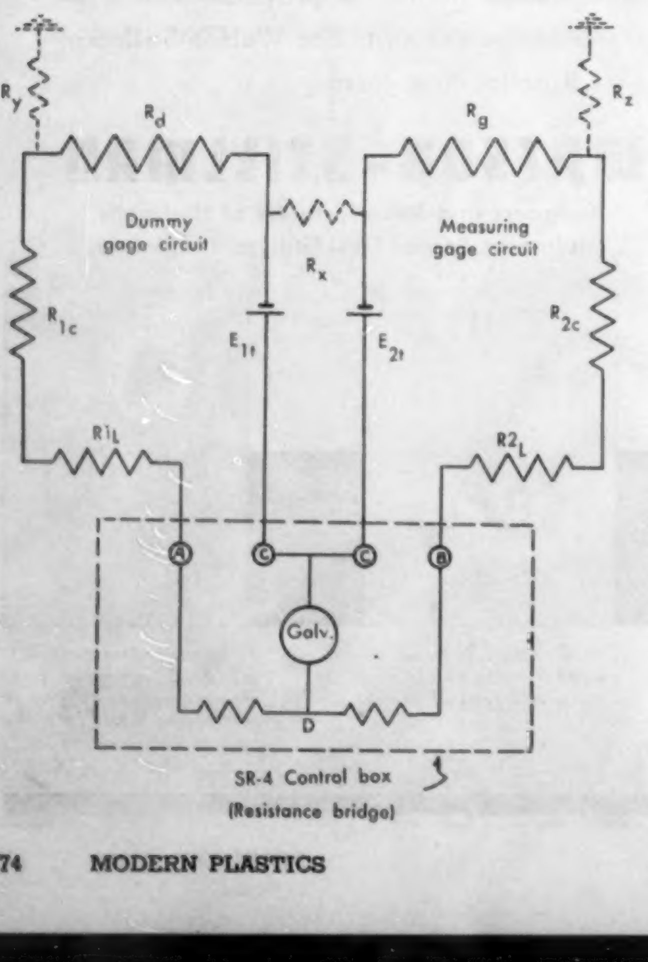
R_{2c} refers to contact resistance in the gage arm.
R_{2L} refers to lead resistance in the gage arm.
R_{1c} refers to contact resistance in the dummy arm.
R_{1L} refers to lead resistance in the dummy arm.
R_d refers to the dummy gage resistance.

Consequently, if micrometer and decade readings are to reliably indicate the strain taking place in the sample, and its accompanying change in the resistance of R_g, then every precaution must be taken to eliminate, as nearly as possible, all changes in resistance except that of R_g, caused by the strain of the specimen. It must be kept in mind that all resistances change with temperature, and consequently the resistance of the leads, R_{1L} and R_{2L}, may be different at different temperatures. Also, wherever different metals are in contact in the circuit, for instance, where the copper lead is connected to the constantan element of the gage, a thermoelectric e.m.f. may be generated. Such a possibility is represented in the diagram by E_{1T} and E_{2T}.

Methods of eliminating or reducing unwanted resistance changes.—Two general methods of reducing error in these measurements may be used:

1. The circuit may be set up in such a way that the unwanted resistance changes in the gage arm are approximately equal to the corresponding resistance changes in the dummy arm, and the two thus effectively cancel each other.

29—*Circuit diagram representing possible sources of error in resistance wire strain gage measurements*



2. The unwanted resistance changes may be reduced to a minimum in each of the arms.

The various components of the circuit and the errors associated with each will now be considered:

1. Resistance of the leads (R_{1L} and R_{2L})

The resistance of a wire depends on length, cross section area and temperature as follows:

$$R = \rho_0\frac{L}{A}(1 + aT)$$

where

ρ_0 = the resistivity of the conductor at 0° C.
L = length
A = cross section
a = temperature coefficient of resistivity
T = temperature in ° C.

Since any change in R_{1L} or R_{2L} with temperature will be proportional to R_{1L} or R_{2L} it is desirable to reduce them to a minimum by using copper leads (low ρ) of fairly heavy gage (large A) and as short as is practical (small L). Furthermore, by using the same wire and same lengths for elements in the dummy circuit as for their corresponding elements in the gage circuit, the resistance R_{1L} and R_{2L} will be equal, and changes caused by temperature changes will balance out, provided the two leads remain at the same temperature at all times.

2. Contact resistances, R_{1c} and R_{2c}

Contact resistances probably give more trouble than any other single factor. For this reason it is necessary to carefully solder all connections to the gage leads, and at all other points in the circuit where the connection will be more or less permanent. A non-acid flux, such as wood rosin, must be used in order to avoid small galvanic cell e.m.f.'s.

The switches now used by us are radio selector switches with silver-plated contacts, and usually work satisfactorily. However, after being used for a few months they are likely to become fouled and cause rather large errors, or even make balance impossible. The contact points should be cleaned with fine sandpaper or emery cloth occasionally. The connections of the main leads to the bridge binding posts also may give trouble. All terminals must be clean, and the posts should be tightened firmly, but not so tight as to injure the terminal.

3. Thermoelectric potentials

This occasionally gives trouble but when such a potential is suspected, it may be detected by observing the galvanometer zero with the bridge turned off, then balancing the bridge by bringing the deflection back to the zero previously found. If reversing the battery now produces a deflection, either thermoelectric potentials, or contact potentials of the galvanic cell type are present.

Failure of bond between gage and specimen.—Proper precautions must be used in cementing and drying the gage. However, the cement of the cellulose nitrate type which is ordinarily used for room temperature work must not be too thick, nor can it be too thin. Also, the specimen surface may be slightly roughtened with fine sandpaper or emery cloth. It is safest to test the cement and technique of application for a good bond before actually attaching the gages. The freshly cemented gages should dry at least overnight before being used. For work at elevated temperatures, special high temperature gages and cement should be used.

Shorting or grounding of arm circuits.—Another very important source of error is the presence of poor electrical insulation at any point between the dummy circuit and ground, the gage circuit and ground or between the two circuits themselves. Leakage through poor insulation may be represented on the diagram by the dotted-in resistances, R_x, R_y and R_z. This source of error is likely to give trouble with changes in relative humidity.

Obviously, the way to reduce it to a minimum is to be certain

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that every portion of each circuit is well insulated. Wire with moisture resisting insulation should be used. Soldered connections to the main cables should be made well apart. It might be worthwhile in variable humidity work to dip the final cable with attached leads into liquid paraffin.

Suggested method of checking SR-4 circuits for errors.

1. Changes in dummy circuit resistance may be detected by replacing the entire gage circuit with a standard resistance of the appropriate value, and balancing the dummy against the standard. If this is done before starting the creep run, and at regular intervals thereafter, changes in dummy circuit resistance may be detected. An alternative method would be that of replacing the dummy gage itself by the standard resistance. In either case, the standard should be connected carefully by soldering to short, low-resistance leads.

2. Since the dummy and gage circuits are similar, changes in the dummy circuit resistance, detected by the above method, reflect the likelihood of *unwanted* changes in the gage circuit. If such changes are suspected, they may be detected by replacing the measuring gage itself by the standard resistance. Two standard resistances, one for replacing the measuring gage, the other the dummy gage, could be used to good advantage for checking the remainder of both circuits.

Creep and time-fracture

(Continued from page 148) test conditions described, would sustain a stress of approximately 3900 p.s.i. 45 percent of the short-time tensile strength, for 1000 hr. before fracture.

Two curves are shown for the methacrylate material. The data for the lower line were taken from specimens tested under a comparatively and unavoidably large variation in temperature and humidity, and resulted in lower time-fracture strengths, especially in the high stresses. It is possible that the effect of this variation in conditions may become negligible as the stress decreases. The upper curve for the methyl methacrylate shows a pronounced change to increased slope at approximately 300 hours. A similar but comparatively slight change is also noted in the lower curve at approximately 250 hours.

A change to increased slope was noted in tensile time-fracture tests on notched and polished specimens of a polyvinyl chloride plastic, a thermoplastic material.[8] The effect of both vee and round notches was reported as an increase in slope of the time-fracture curves. A similar change in slope was reported for time-fracture tests of steels at high temperatures, as a result of intergranular oxidation.[9] It is possible that at stresses resulting in failures only after considerable time, the crazing fissures observed on the surface of the methacrylate material may have contributed to a notch effect resulting in this change of slope.

Elongation at fracture.—The effect of time to fracture on the total elongation at fracture may be seen in the creep curves of the materials. There are not sufficient data for the phenolic laminates for any general conclusion. The tests of the methacrylate plastic at standard conditions indicate that the total elongation increased slightly with time to failure (Fig. 4). The tests under the more variable conditions (Fig. 5) show somewhat greater elongation with considerably more variation, than those at standard conditions.

The results of creep tests on cellulose acetate reported by Findley[3, 4] indicate a decrease in total elongation at fracture with increasing time to failure. Similar tests on polyvinyl chloride at comparatively high stresses and short time to fracture, on both polished and machined face specimens, reported by Buchmann,[10] indicate that the total elongation at fracture increased for polished specimens and decreased for notched specimens. The faces of the specimens used in the tests reported herein were the original polished surfaces of the sheet and tended to minimize any notch effects in the specimen until severe crazing developed.

Surface appearance of tested specimens.—Crazing lines appeared on the surface of the methyl methacrylate specimens within a short time after the application of load, in the stress range of 3650 to 5450 p.s.i. covered in these tests. These lines appeared after approximately 0.02 in. deformation had occurred in the 2-in. gage length and remained in the specimen after failure. The crazing lines started in the gage section after sufficient deformation had occurred, and extended, as the deformation increased, into the shoulder of the specimen. The uniformity of the crazing was believed to be an indication of uniform loading. One specimen, stressed to 2470 p.s.i., developed only 0.01 in. deformation in 1000 hr. of test without any apparent crazing.

The surface of failure of the methacrylate specimens appeared similar to a fatigue failure in steel.[10] Transverse cracks starting in crazing lines at either the center or edge of the width of the specimen progressed across the cross-section of the specimen until the area supporting the load was sufficiently small to fail in tension. The area of progressive failure was smooth, and that of the final tension failure was rough and granular. There was no apparent localized reduction in area in the gage section of the methacrylate material just before failure. The deformation developed approximately uniformly over the gage section. This same type of failure in long-time loading tests was reported by Findley[3] for cellulose acetate material and by Buchmann[10] for polyvinyl chloride material, at room temperature.

A few fine cracks or crazing lines appeared on the surface of several specimens of the fabric-base phenolic laminate. In the range of 10,500 to 11,500 p.s.i., slight cracks appeared in the resinous surface of the fabric-base sheet after approximately 30 hr. under load, at a deformation of 0.0147 to 0.0172 in. per in. strain over the gage section, and were not visible after failure occurred. As only a few tests of paper base material have been completed at this date, sufficient data are not now available on the crazing of this material. However, tests now in progress for over 4000 hr. at stresses of 8000 to 10,500 p.s.i, show no visible cracking or crazing. The surface of failure of the fabric-filled laminated phenolic was of fibrous character in a plane transverse to the direction of the tensile stress. The surface of failure of the paper-filled laminated phenolic was granular in appearance, in a plane transverse to the direction of the stress.

It is to be noted that although the data reported herein may be considered as representative for the materials tested, there may be considerable differences between these and other test results due to the variation between sheets of the same type of plastic material.

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[8] W. B. Klemperer, "Stress Pattern Crazing," Contributions to Applied Mechanics and Related Subjects, Theodore Von Karman Anniversary Volume, California Institute of Technology (1941).

[9] A. E. White, C. L. Clark and R. L. Wilson, "The Fracture of Carbon Steels at Elevated Temperatures," Trans. Am. Soc. for Metals *25*, 863–888 (Sept. 1937).

[10] W. Buchmann, "The Strength and Permissible Loading of Polyvinyl Chloride Plastics," Z. VDI. *84*, No. 25 (June 22, 1940).

Polyethylene

(Continued from page 99) when available, for containers, including collapsible tubes for food, cosmetics and the like. The inertness of the material makes it useful in gaskets and in battery parts. Extruded as flexible tubing or more rigid piping, polythene may be expected to find use for the handling of a wide variety of fluids.

Like nylon, polythene is of crystalline structure and in extruded form can be oriented by cold-drawing, with resulting large increase in tensile strength. Molded by injection or compression, polythene should find many uses by virtue of its toughness, low-temperature flexibility, low density and excellent electrical properties. Deposited as a coating by flame-spraying or from solutions, polythene will form coatings which are waterproof and also inert toward a wide variety of chemical agents. Alone or compounded, polythene has valuable properties as an adhesive. The properties of polythene make it well suited to serve as a covering for electrical wiring and cable. This has been adequately demonstrated by performance under service conditions.

For some purposes, polythene is used without modification. For others it is compounded with compatible resins, waxes or the like. Thus, for example, its rigidity may be reduced by the incorporation of polyisobutylene, or it may be compounded with waxes for the preparation of adhesives. Compounding with such ingredients is accomplished on heated mixing rolls or in a masticator mixer. Auxiliary ingredients such as pigments, dyes and fillers likewise may be incorporated into polythene by the use of such equipment.

The extrusion of polythene involves no special difficulty when suitable equipment is available and reasonable attention is given to control. Illustrative of the technique is the procedure developed for covering wire with unplasticized polythene to make a quarter-inch cable. For this purpose it is best to use an extrusion machine of the type employed with plastics. The wire is preheated and fed at a uniform rate. The polythene in granular form is fed cold into the screw which may be cooled with water if necessary. Screens at the breaker-plate prevent the passage of lumps. The temperature of the throat, head and die are carefully controlled, e.g., by circulation of oil. The freshly extruded material is cooled slowly, first in hot water and then in cold water. This slow cooling is required because of the extremely high coefficient of thermal expansion of polythene. The decrease of volume in cooling from 120 to 20° C. is approximately 12.5 percent, and more than half of this takes place during a rapid crystallization between 120 and 80° C. Too rapid cooling would cause the surface of the coating to be hardened while the center remains still soft. The decrease in volume during further cooling would result then in the formation of voids in the interior of the mass. Mixtures of polythene with polyisobutylene can be extruded similarly and with less care in the cooling because the exterior does not become so rigid when cooled.

Polythene can be successfully molded by compression in positive molds. The thermal shrinkage is large. Hence it is particularly important to hold the molding under full pressure during the cooling, and desirable to cool relatively slowly in order to minimize the development of strains in the article. To make sound moldings, the material should be heated to at least 120° C., but temperatures above 160° C. should be avoided because they cause the article to adhere to the mold. An external lubricant may be applied to the surface of the mold to facilitate the removal of the molded article.

Polythene can be handled also in standard automatic in-

TABLE I.—TYPICAL PROPERTIES OF POLYTHENE

(Data given herein represents standard commercial grades of material and standard methods of testing except where otherwise noted.)

Property	*Test result*	*Test method*
Specific gravity	0.92	D71-27
Tensile strength, p.s.i.		[1]D638-42T[2]
at −70° F.	5000	
at 77° F.	1700	
at 170° F.	700	
Elongation, percent at 77° F.	30–500	[1]D638-42T[2]
Modulus of elasticity, 77° F. p.s.i.	14,600	[1]D638-42T
Flexural strength, 77° F. p.s.i.	1700	D650-41T
Stiffness, 77° F.	13,300	[1]D747-43T
Impact, Izod, −70, 77, 170° F. ft./lb./in.		[3]D256-41T
Rockwell	13R	ARL. M-29
Flow temperature, ° C.	104	D569-43
Deformation under load, 122° F. percent	20	[4]D621-43
Strain release temperature, ° C.	75–80	ARL. M-15
Yield temperature, ° F.	140	[1]ARL. M-8
Heat distortion temperature, low load, ° F.	122	[5]D648-42T
Specific heat, cal./gm./° C.	0.5	
Coefficient of expansion, per ° F.	10.5×10^{-5}	D696-42T
Thermal conductivity, Btu./hr./ft.²/° F./in.	2.96	D325-31T
Dielectric strength, step by step, V./M.	1000	[6]
Volume resistivity, ohm-cm.	10^{17}	[6]
Water absorption, per cent	0.01	D570-42
Flammability, in./min.	Ignites and burns slowly	
Outdoor exposure	No discoloration	[7]
Accelerated weathering	No discoloration	[7]
Methods of working	Inj., compr., extr., cal.	
Basic color	White translucent	
Resistant to	Water, alkalies, acids, and oxygenated solvents	
Not resistant to	Chlorinated solvents, aliphatic and aromatic hydrocarbons at elevated temperatures	
Outstanding for	Moisture resist., elect. prop., toughness, workability	
Major uses	Electrical insulation, tubes, containers	

Notes:

[1] Average values reported. May vary considerably with method of specimen preparation (inj., comp., ext., etc.).
[2] Tensile tests made at speed of 1 in./min.
[3] Does not break at room temperature in 4 ft./lb. machine. 0.50 ft./lb. at −70° F.
[4] Tests run at a load of 1200 p.s.i. since the 4000 p.s.i. loading of the standard test was designed for more rigid plastics.
[5] Maximum fiber stress 66 p.s.i.
[6] Values given are for early experimental polythene.
[7] Tensile strength and elongation drop in absence of stabilizer.

jection-molding equipment with cylinder temperatures of 175–260° C. (350–500° F.), and die temperatures usually in the vicinity of 60° C. (140° F.).

Sheeting of polythene in various thicknesses can be made by calendering, by extrusion or by forming a block attached to a bedplate and slicing it as is done in the manufacture of the pyroxylin plastics. Massive polythene is readily machined with wood- or metal-working tools.

Waterproof and chemically resistant coatings of polythene can be applied from hot solutions of the resin in, e.g., xylene, or from dispersions in water or organic solvents, or by flame-spraying or "hot-melt" technique. A solution in xylene should be prepared at a temperature of at least 80° C., preferably 100° C. or more, and should be kept hot during its application. A film applied from solution or dispersion should either be dried at a temperature above 100° C. or fused after it has been dried, to ensure a continuous and adherent film.

Films of polythene can be joined readily by heat-sealing, and massive polythene can be welded satisfactorily if care is taken to prevent excessive oxidation. For patching and welding, a mixture of polythene with polyisobutylene is more satisfactory then polythene alone.

The supplies of polythene heretofore available have been used in the production of items urgently needed by the Armed Forces. At present the material is available in production quantities only by specific authorization of the War Production Board under Conservation Order M-348. But small quantities for experimental purposes may be obtained on proper application.

Ethyl cellulose

(*Continued from page 134*) variety of colors is available in transparent, translucent and opaque ranging from clear to pastels to jet black. In Table I are listed some of the properties of representative extrusion grades of this plastic.

TABLE I.—PROPERTIES OF REPRESENTATIVE EXTRUSION GRADES OF ETHOCEL PLASTIC

Property	*ASTM method of test*	*Type ER Grade M*	*Type ER Grade S3*	*Type ELT Grade H*	*Type ELT Grade S*
Flow temp., ° F.	D 569–41T	290	270	300	280
Extrusion temp., ° F.	....	370	350	360	340
Specific gravity	....	1.15	1.16	1.09	1.08
Tensile strength, p.s.i.	....	6000	4000	6500	4000
Elongation, %	....	50	65	30	40
Impact strength, ft.-lb./in. notch	D 256–43T	6.5	7.0	5.5	5.5
Heat distortion, °F.	D 648–41T	165	152	160	150
Burning rate, in./min.	D 635–41T	1.0	0.8	1.2	1.4
Dielectric constant, 10^3 cycles	D 150–42T	3.7	3.8	3.4	3.4
Power factor, 10^3 cycles	D 150–42T	0.024	0.028	0.009	0.010
Water absorption, 24 hr., %	D 570–42	2.0	1.7	2.0	1.8

Synthetics in shoes

(*Continued from page 98*) plasticizer and the degree of elasticity obtained is known only empirically for a few cases. The same holds true for other important physical properties necessary for soling, e.g., low-temperature toughness. Undoubtedly the major problem of the industry dealing with non-rigid plastics is the fundamental physical chemistry of plasticization, so that further advances in this field can be made on a more logical basis.

If the required properties for shoe soling are examined and are checked against the properties as known for the elastomers (including the vulcanizable type), it is found that several of these plastics seem to have promise for the purpose. Those of outstanding importance are 1) the vinyl acetals, formed by the acetalization of polyvinyl alcohol by various aldehydes, 2) the co-polymers of vinyl chloride and vinyl acetate and 3) the so-called synthetic rubbers considered as a group. In mentioning these examples, two points should be borne in mind, viz.

1. New compounds are appearing from time to time which appear to have much promise. The opportunities afforded by synthesis to produce materials in tailor-made fashion, and many as yet unexplored avenues in plasticization, undoubtedly will bring forth new materials for use as soling.

2. In the consideration of the types mentioned above or of any synthetic, due care must be exercised in formulation in the light of the property requirements listed in earlier sections of this discussion.

Synthetic soling compositions

These replacement materials may be used generally in either of two ways, viz., 1) with no filler, in the form of soles molded directly or cut from slab stock, or 2) with a woven fabric filler cut from slab stock. The thermoplastics have in general a high degree of permanent set and in most cases also a relatively low tear strength. Both of these deficiencies are obviously undesirable in a soling material. The inclusion of a woven fabric filler offers a simple means of improving very greatly these possible deficiencies. Soling has been used recently of course on a considerable scale with no filler other than a small amount of pigment, but the possibilities mentioned above should be carefully considered.

When this laboratory was requested to undertake experimentation in the field of replacements for sole leather in view of the serious situation in supplies of sole leather, the use of thermoplastics with a woven fabric filler was chosen for reasons cited above. In the summer of 1942, a soling material was produced which was incorporated into the standard Canadian Army ankle boot. The soling is very simply manufactured. The polyvinyl butyral, mixed on friction rolls in the usual way, is friction calendered into a medium cotton duck of rather open weave. Then a number of layers of this impregnated cotton are laminated together under heat and pressure. Sufficient heat is used to soften the resin compound so as to obtain flow, and with a relatively low pressure, a material is obtained which may be regarded as a continuous plastic material having incorporated in it a strong reinforcing filler. The fabric stabilizes the resin against permanent set and adds tremendously to the tear strength without detracting from the inherent resiliency and low temperature flexibility of the resin. The overall cost of the soling material obviously is greatly reduced. Working trials in shoe factories show that the material handles very well in all operations except for the minor dis-

advantage in buffing of edges as noted earlier. Grooving, stitching and nailing properties are excellent, and the workmen handle the material exactly as they would leather. There is no possibility of chemical action on cotton or linen thread, and laboratory tests have shown that stitching holds well. Efficiency in use with standard screw construction is outstanding.

The wear resistance on the laboratory leather abrasion machine (U. S. National Bureau of Standards type) is from two and one-half times to four times that of high-grade sole leather. Several hundred pairs have been worn in field trials by various Canadian military units, and the reports on wear have been very favorable. Various isolated trials on civilian shoes have also been made with uniformly good wear results.

In the evaluation of a synthetic soling composition it must be considered that the laboratory can provide only provisional information and that eventually large-scale service trials under proper supervision must be made. The correlation between laboratory abrasion machines and actual wear trials although showing a general trend, is not as clean-cut as might be hoped. However, laboratory wear tests do serve a valuable purpose in a preliminary evaluation. In addition, our evaluation includes moisture absorption, toughness at $-40°$ F., tendency to delamination, flexural fatigue and gluing properties. Calendering leads to orientation and consequent unidirectional properties. The resultant effects on wear resistance must be taken into account.

Conclusion and acknowledgments

The situation with regard to synthetic shoe soling may be stated succinctly as follows. The user of soling is interested in comfort, cost and wearing quality. Any material which shows at least a satisfactory degree of comfort in comparison with sole leather, which is reasonably competitive in price and which yields very much longer wear in service, would appear likely to prove an important factor in the future for use as shoe soling. The use of synthetics for shoe uppers and insoles must await the development of a material which possesses among other properties, a good degree of ventilating power.

The writer wishes to express his thanks to Gerald G. Graham and Robert G. Schnarr for their valuable assistance during the course of this work.

Furane resins

(*Continued from page 104*) of the representative characteristics determined by ASTM methods are presented herewith:

Furane resin pulp laminates

Tensile strength, p.s.i.	9000–10,000
Flexural strength, p.s.i.	11,000–12,000
Modulus of elasticity (bending), p.s.i.	1,200,000
Charpy impact test (unnotched), ft./lb.	2.0–3.0

Unfilled cast furane resins

Water absorption:	
24 hr., percent	0.06
48 hr., percent	0.1
Resistance to solvents	Excellent
Resistance to acids	Excellent
Resistance to alkalies	Good
Color possibilities	Limited to dark only

Luminescent pigments

(*Continued from page 107*)

Architectural.—Decoration and design, ornaments, directional and identification signs and markers.

Industrial.—Dials and instruments, signs and markers, identification buttons, safety warnings.

Home.—Radio and television dials, night orientation markers, television room decoration and markings, table decorations, flowers, ashtrays, name-place markers, switch and name plates, belt and shoe buckles, powder and rouge compacts, cigarette cases, dresser sets, purse trimmings, novelty jewelry, decorative wall coverings, stair riser plates, mats for pictures.

Paints.—In which resins as the vehicle will play an important part for decorative paint effects and as aids to lighting efficiency.

Photo-templet.—Reproductions of lofting drawings or layouts in which phosphorescence furnishes the light source for exposure without the need of a camera. Templet supports may be of plastic as well as of metal or wood.

There are many places where luminescence can be combined with plastics to furnish a useful or decorative product that provides non-glaring light in darkness, or to increase the use of lighting systems.

Pill boxes

(*Continued from page 111*) according to the molder, unsatisfactory. Automatic printers which this molder has used to imprint mechanical pencils proved too slow, even though fed automatically from a hopper. Finally, girls were trained to ink the covers with hand rollers, the setup for which is shown in Fig. 6. After a girl, not shown, places all the lids face up on the table, the girl at the right arranges the lids in an orderly row in the conveyer trough, while the third girl at the left, inks them with a hand roller and pushes them onto a gravity conveyer. In this printing operation the roller is held at exactly the correct height by guide strips, thereby making it possible to cover completely the raised letters with ink, yet prevent inking the balance of the lid surface.

The lids then pass from the conveyer onto a moving belt which carries these freshly inked parts under a battery of lamps which dries them, better, faster and at a lower cost than any of the elaborate mechanical equipment which was tried out. This illustrates graphically one of the large problems faced by most custom molders—that of improvising equipment and systems for quickly and economically carrying out necessary production operations. The belt system not only serves to dry the ink quickly but also acts as an inspection medium. After passing under the infrared lamps, the now thoroughly dry covers go to the final inspection table, after which they are ready for assembly and packing.

With this setup, each printing station, manned by a crew of four girls, produces covers at the rate of 4500 per hour. Three such lines are now in operation, but due to the great need for larger shipments, a fourth unit, complete with conveyer belts and lamps, is being assembled. With this fourth unit in operation, covers will reach the shipping department at the rate of 18,000 per hour.

Credits—Material: Fibestos. Molded by St. Louis Plastics Moulding Co. for Upjohn Co.

Lay that pistol down

(Continued from page 101) has a weight of $2^1/_8$ lb., and contains a hollow barrel and a slot for the trigger. The embossed screw heads on the four prongs, two of which are visible on the grip end of the weapon (Fig. 4, A), simulate the screws in the real firing revolver. The slot provides for the insertion of a cast bronze trigger (Fig. 4, C) against which is placed a compression spring (E) which extends into the hollow barrel. Adjustable pressure is exerted against this spring by means of a small threaded plug in the barrel. The adjustment of trigger tension is effected by tightening or loosening this plug with a small screwdriver inserted in the end of the barrel.

A single-cavity mold is used for the molding operation and is constructed with two cams, or removable plugs, one to hold the insert in the proper position and the other to core out the trigger and guard recess. Of necessity, these cams are hand-operated. The insert itself is cast from a special CT metal which will withstand a specified drop test. The design of this casting had to be such as to give exactly the same weight and balance as are found in an actual .45. According to the molder, the solution of this balance problem entailed the most intricate and difficult procedure. The four screw heads on the insert not only increase the resemblance of the plastic gun to its original but aid in holding the insert in place in the mold.

Several difficulties were encountered in the molding operation. First, as has already been indicated, it was imperative that the insert be accurately held in place. Second, the cycle had to be maintained at a speed slow enough to eliminate any danger of shrink marks in the heavy sections, but not so slow that the finish would be impaired. While the mold is closed, the press operator employs his time in removing and finishing the gate, the only finishing operation necessary in producing this pistol. The component parts of the insert, including the trigger spring, trigger guard and spring adjusting screw, then are assembled. The inspection department checks all details including the correct adjusting of the trigger adjusting screw. Packed 50 pistols to the case, these units are now being shipped to all Naval training centers.

Credits—Material: Lumarith. Manufactured by Cruver Manufacturing Co. for U. S. Army and Navy.

A new turn to the spigot

(Continued from page 118) from which the stripper plate removes the molded pieces.

Both the spigot retainer nut and valve retainer nut are tapped in a secondary operation so as to eliminate all danger of shrinkage and insure that the threads are free of the fins and flash or mold parting line marks. The rear end of the spigot is also threaded in a die. For cutting the plastic, both taps and dies are specially sharpened and a heavy oil is used as a lubricant so that maximum machining speeds may be employed without overheating or tearing the material.

The hole through the spigot which was started by the movable pins in the die is finish drilled as is the hole through the valve. Following this operation the valve is lapped or polished to its seat in the spigot body. Finally, the whole unit is assembled and tested under pressure. Flexible washers are provided to help form a seal after the spigot is installed in the keg and the spigot retainer nut tightened, since the hole in the keg may vary in size and a soft seal is required to prevent leaks. *(Please turn to next page)*

The number of operations performed on these plastic parts, the ease with which they are carried out, and the unusually satisfactory results of tight fit and smooth function obtained by thus treating plastics almost as a metal, are significant from the point of view of mold design and plastic technique. Here the cellulose acetate butyrate blanks are brought in from the molding room, much as are die-cast parts, for fabricating operations usually built into the plastic mold. The specialized injection problems attendant on the operation of a complex and costly mold are replaced by the more usual ones of drilling, tapping, lapping and buffing, all of which can be performed easily by average factory help. Although this combination of injection with extensive fabricating operations is rather an unusual procedure in present-day molding, it deserves the attention of designers considering new applications for plastics. From a cost and production standpoint, it is sometimes overlooked that the use of unskilled labor to trim and finish plastics is more economical in the end than the expense incidental to the design, manufacture and operation of elaborate injection molds.

Credits—Material: Tenite II. Molded by Ohio Plastic Co. for Zanesville Stoneware Co.

News of the industry

(*Continued from page 166*)

★ REPRESENTATIVES OF 10 LARGE MANUFACturers of synthetic resin adhesives met in New York on Jan. 13 and formed an association aimed primarily at "offering cooperation in utilizing synthetic adhesives for war products and unified industry action on industry-wide problems in dealing with the armed services and other government agencies." The group will be known as the "Resin Adhesive Manufacturers Association" and includes a large share of the companies now producing synthetic resin adhesives for further sale or manufacture.

The officers of the new association are: President, W. F. Leicester, vice-president Casein Co. of America; Vice-President, C. F. Hosford, Jr., president, Pennsylvania Coal Products Co.; Secretary-Treasurer, J. E. Waller. The Board of Directors consists of the president and vice-president and James L. Rodgers, Jr., of Plaskon Division of Libbey-Owens-Ford Glass Co. Two additional directors are to be elected in a subsequent meeting. The need for the new organization was recognized through the activities of the Plastics Materials Manufacturers' Association, wherein the assistance to industry and the Armed Forces on those products indicated a similar service could be rendered in connection with the utilization of these adhesives. The new association includes those concerns whose adhesives are based on phenol, urea, resorcin, melamine, vinyls and alkyd resins.

An important phase of the program was the appointment of a Technical Advisory Committee including representatives of each member company. Other objects of the association as outlined in the meeting included promotion of the general welfare of the resin adhesive industry, increasing the use of resin adhesives in the arts and industries, study ways and means for eliminating waste in production and distribution, to promote safety, to encourage research and to promote improvements in the quality of resin adhesives.

Representatives of the following companies attended the organization meeting: Plaskon Division, Libbey-Owens-Ford Glass Co.; American Cyanamid Co.; Casein Company of America; I. F. Lauchs, Inc.; Durez Plastics & Chemicals, Inc.; Catalin Corp.; Monsanto Chemical Co.; Reichhold Chemicals, Inc.; Pennsylvania Coal Products Co.; and Marblette Corp.

(Please turn to next page)

★ PLASTICS MATERIALS MANUFACTURERS ASSOciation reelected James L. Rodgers of Plaskon Div., Libbey-Owens-Ford Glass Co., as president and William Thiele of Catalin Corp., as vice-president. John E. Walker will continue as secretary-treasurer. The group also announced the expansion of technical activities with the appointment of F. H. Carman as general manager.

With a change in the by-laws of the Association, a Board of Directors was elected for the year 1944. The members of the Board are the president and vice-president and A. E. Pitchor, general manager, Plastics Div., E. I. du Pont de Nemours & Co., Inc.; J. C. Brooks, vice-president, Monsanto Chemical Co., Plastics Div.; R. Hoover, Plastic Material Div., B. F. Goodrich Co.; and Harry Dent, president, Durez Plastics and Chemical Co.

It is planned to broaden the Association activities during the coming year especially along technical lines which had already been well established during 1943. The Technical Committee composed of C. J. Romieux, chairman; Clinton Blount; and S. E. Palmer was reappointed.

In the fall of 1942, Donald M. Nelson, chairman of WPB, asked the plastic materials manufacturers to collaborate in exchange of technical information respecting the physical properties of their materials, the methods of testing and in the further improvement and development of these testing methods. It was understood that the information will be available to all manufacturers and to the Armed Forces. The purpose of the book, "Technical Data on Plastic Materials," published in the latter part of 1943, is to acquaint the user with the nature, particular merits and utility of various plastic materials, and with property values as measured by recognized methods. All available measurements of any common interest were included in this book.

The expanded technical activities of the Association planned for 1944 comprises: 1) continuation of technical committees; 2) data publication to include all possible information from government sources and new data from members; 3) organization and presentation of joint industry opinion to Army, Navy, Air Forces and other government agencies on specification matters; 4) continued cooperation with American Society for Testing Materials and other organizations interested in properties of plastic materials; and 5) expand and improve the data book along any lines that will make it still more effective to the users of plastic materials.

A mechanism for expediting the above activities of the Association is being set up by the General Manager's office. Mr. Carman was associated with WPB in Washington from April 1941 through Dec. 1943. Originally appointed to handle the allocation of neoprene, he was responsible for allocations of all synthetic rubbers and vinyl polymers through Aug. 1942. In August 1942 he was appointed Chief of Plastics Section in the Chemical Division with responsibility for allocations, plant expansions, priority assistance, man power problems, etc., for all thermoplastic, thermosetting, and vinyl resins; adhesives; and acrylonitrile, the latter being used in production of synthetic rubber.

★ MRS. JEAN NICHOLSON HAS RESIGNED FROM Plastics Section of WPB to become associated with James H. Savage, plastics consultant, who recently moved to new offices at 113 W. 42nd St., New York.

★ SHARPLES CHEMICALS, INC. MOVED ITS EXECUtive offices from 23rd and Westmoreland Sts., Philadelphia, Pa., to new and larger quarters located in the Fidelity-Philadelphia Trust Bldg., 123 South Broad St., in the same city.

★ ANNOUNCEMENT HAS BEEN MADE OF THE REcent promotion of P. J. Ryan to the post of vice-president in charge of the Detroit plant of Reichold Chemicals, Inc. In his new position Mr. Ryan will have complete supervision over all production and technical development at the main plant but will continue to act as technical advisor to the board of directors.

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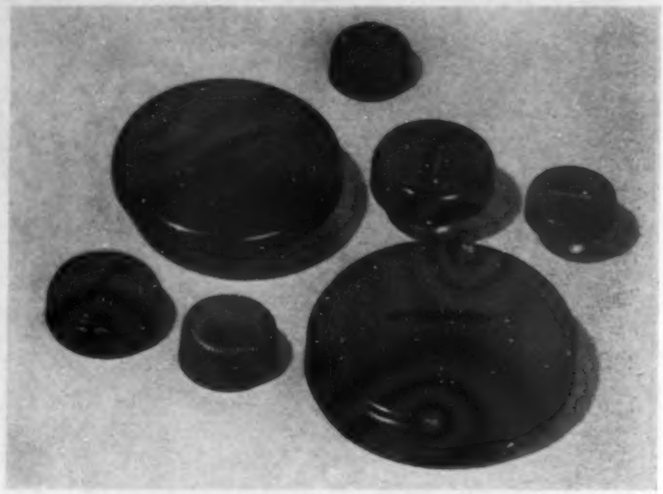

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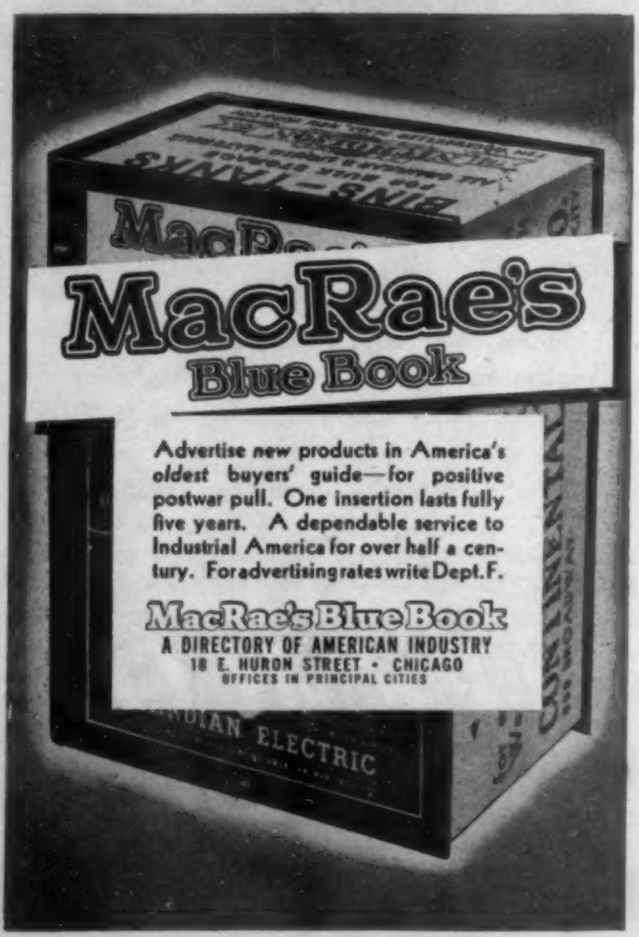

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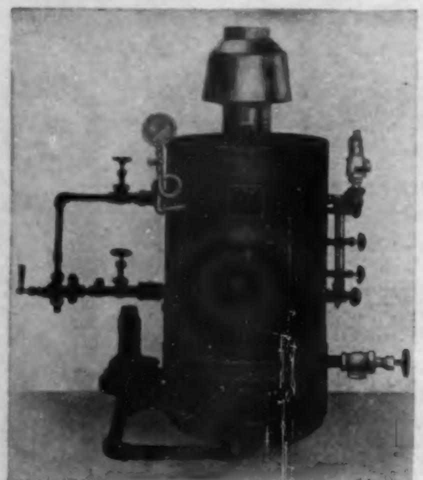

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FOR SALE: 1—Watson-Stillman Hydro-Accumulator, 5½" ram; 2—Farrel Birmingham Hydraulic Presses, 24 x 24, 12" ram; 1—W. S. 15" x 18" Hydraulic Press, 10" ram; 1—14" x 24" Press, 9" ram; 4—24" x 55" steel cored Heating Platens; 4—W. & P. Mixers; 1—Elms Hydraulic Pump, 6.5 GPM at 7500# pressure PSI; 4—Semi-Automatic 100-ton Hydraulic Presses, platen area 20" x 36"; Adamson 6" Tuber; Dry Powder Mixers; Pulverizers, Grinders, etc. Send for complete list. Reply Box 447, Modern Plastics.

WANTED: Small or medium sized plastic molding plant with either hydraulic extrusion or injection equipment with or without tool shop. Advise full details. Reply Box 788, Modern Plastics.

IN THE MARKET FOR: Stainless Steel or Nickel Kettles, Vacuum Pan, Preform Machine and Mixer, Hydraulic Presses. Reply Box 825, Modern Plastics.

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WHITE CELLULOID CUTTINGS

Analysis: 25% Cotton, 52% White Cellulose Nitrate, 13% Camphor, 10% Zinc Oxide Pigment.
Shipment can be made in wooden cases, and bales of 700 to 800 lbs.

SAMPLES ON REQUEST
A. J. FRANK & SON
Hamilton — Canada

MANUFACTURERS—If you have any Washington problems, either Governmental or private business, or lack manpower to service Washington accounts, contact us. We have 12 years experience in Washington field, both Government and private business, and all services rendered by us are at reasonable cost and in strict accordance with established Government Regulations, specialists in renegotiation and qualified also for distributorships. Write Box 922, Modern Plastics.

PLASTIC ENGINEERING: Plastic materials formulas, adhesives formulas, thermosetting resin formulas, laminating and bonding resin formulas. Product Design and Engineering. Plastic plant engineering and layout. Manufacturing contacts and sales outlets. Plastic Engineering, P. O. Box 100, Midland, Mich.

CHEMICAL SALES ENGINEER

Age 41. Excellent personality and appearance. Broad industrial chemical background. Interested opportunity potential minimum earnings of $8000. Would prefer chance to build new territory. Reply Box 923, Modern Plastics.

MANUFACTURERS ASSOCIATES
West Coast Sales Agents
PLASTICS

From Raws to Finished Products
Accounts Solicited—References Exchanged
P. O. Box 749, Glendale, California.

FOR SALE: Boilers, Mears-Kane-Ofeldt make, used only about one year, excellent condition. 4—1 H.P. with injectors, $125.00 each and 1—2 H.P. with injector, $185.00. Reply Box 924, Modern Plastics.

WANTED: Die Setter and Maintenance Man with experience on Reed-Prentice machines. Good Opportunity for right man. Reply Box 926, Modern Plastics.

WANTED

MATERIALS TECHNICIAN with chemical or mechanical engineering background to take care of Materials Department in well known plastics molding company located in eastern Pennsylvania. Experience in purchasing, compounding, and preforming desirable. Write full details to Box 925, Modern Plastics.

WANTED: Injection Department Foreman. Well established large eastern molding plant requires the services of an experienced man who knows machines and can handle labor problems. Reply Box 927, Modern Plastics.

WANTED: Experienced Operator for extrusion machine. Good opportunity for right man. Reply Box 928, Modern Plastics.

PLASTICS RECLAIMING PROCESS for sale. Raw materials available; process inexpensive; product tough, flexible. Use f. electr. insulat., shoe soles, etc. Address Box 930, Modern Plastics.

WANTED—Injection molding machine—four ounce—H. P. M. preferred—will pay cash. Reply Box 929, Modern Plastics.

WOODWORKING PLANT now manufacturing wooden handbag frames, desires to make connection with plastics manufacturer or plastics engineer, with view to make similar item or other items. Will also consider consolidating. Amply financed. Address Box 931, Modern Plastics.

EXECUTIVE PLASTICS SALES ENGINEER presently working on West Coast will be interested in discussing direct plant sales connection with West Coast molder or sales coverage for all or part of West Coast area for outside molder. Experience in production and sale of injection, compression, transfer, extrusion and fabrication to aircraft, industrial and commercial accounts. Able to assume complete charge of selling program and show profitable results. Available 30–60 days. Reply Box 932, Modern Plastics.

FOR SALE: 1—Watson-Stillman Hydro-pneumatic Accumulator, 25" x 7" x 48", Capacity 8 GPS, 2550# Hydraulic WP, Complete with 36" x 20' Steel Air Tank, Trip Control, by-Pass Valve, Interconnecting Piping and Fittings, and Southwark Triplex Vertical Hydraulic Pump, 1½" x 6", 11.5 GPM, 2500# WP, Connected to Westinghouse 15 HP Slip Ring Motor with Starter. 2—Deane Steam Pump Company Triplex Vertical Hydraulic Pumps, 6" x 8", 200 GPM, 200# WP, Arr. for Geared M.D. 1—Boomer and Boschert Triplex Vertical Hydraulic Pump, ⅞" x 4", 3 GPM, 4000# WP. 3—New Single Opening 50 Ton Hydraulic Presses, 12" x 12" Platens, Any Desired Daylight, 8" Diameter x 8" Stroke Rams. 1—Southwark, 150 Ton, 2-Opening Hydraulic Press, 24" x 24" Steel Steam Platens, 4" Daylight per Opening, 12" Diameter x 12" Stroke Ram. 1—Royle #1 Tuber, arranged for Motor Drive. 1—Hydraulic Plastics Sheeter, Capacity 24" x 6' Sheets. All Offered Reconditioned, Guaranteed, Prompt Shipment. Drawings and Other Data on Request. Other Sizes of Presses, Pumps, Accumulators, also Motors, Compressors, Boilers, Machine Tools, etc. 1—8 Opening Hydraulic Press, 30" x 52" x 2" Steel Platens, 3" Openings, 2—14" diameter x 23" Stroke Outside Packed Rams, 2500# WP, Complete with 4 Plunger Vertical Hydraulic Pump with 15 HP A.C. Motor, and All Other Operating Accessories. Industrial Equipment Company, 876 Broad Street, Newark (2), New Jersey.

EXTRUSION CAPACITY AVAILABLE: Modern plant will accept open or sub-contract work in all types of extruded products. Our capable engineering staff available for extrusion design and die development, close tolerance and experimental work. Reply Box 934, Modern Plastics.

WANTED SALES REPRESENTATIVES (3)

One for New York State (Excluding Metropolitan area) and upper Pennsylvania.

One for lower New Jersey, Eastern Pennsylvania, entire states of Delaware and Maryland, and the District of Columbia.

One for Western Pennsylvania.

To represent well-established New England firm, on a commission basis. Rivets, screws, screw machine parts, rivet setting equipment. One who has engineering background and associated lines preferred. Reply Box 933, Modern Plastics.

PLASTICS RESEARCH AND DEVELOPMENT ENGINEER with background in Chemistry and theory of plastics wanted by pharmaceutical company in department being established for investigating adaptation of plastics to packaging. Experience in compression, extrusion, transfer, and injection molding desirable. Background in Chemical Engineering helpful. Reply Box 935, Modern Plastics.

WANTED
SLATS OF PLASTIC COMPOSITION

23 to 35" long, 2" wide, 1/4" thick up to 2 ounces in weight in ivory or off-white, must be color fast to sun, warp resisting, to stand up in routing and cutting. Can use 10 million lineal feet at right price.

Write to: Plastic Department,
A. B. Landau, Inc.,
Advertising Agency,
270 Broadway,
New York, N. Y.

TECHNICAL SALES REPRESENTATIVES wanted by established Laminator, Compression Molder and Fabricator. Locations in East and Middle West. Write giving past experience and territory. No objection to non-competing lines. Reply Box 936, Modern Plastics.

DRAFTSMAN-artist desires a position in a plastic mold designing department. Graduate in industrial and architectural design at Cooper Union, New York. Has five to six years of drafting and art experience. Permanently deferred. Will travel to any location. Salary open. Reply Box 937, Modern Plastics.

SALESMAN, married, 39, can furnish availability certificate. 3 years of manufacturing experience, of which 1 year injection molding and extruding. Also machinist with some experience in making injection and compression molding dies. Wishes to travel as direct representative of well established firm. Reply Box 938, Modern Plastics.

PATENTS WANTED

We are interested in purchasing Sole Manufacturing Rights of Plastic or Ebonite articles suitable for English market.

Ebonite Container Co. Ltd.
Belle Isle,
York Way, London, N. 7.

WILL BUY CHEMICAL PLANT—Chemical Engineer "Ph.D." formerly research and Production Manager will buy whole or part of manufacturing plant to produce various synthetic resins, plasticizers, oil-wax products for the textile, paint, paper and allied fields. Need jacketed kettles, mixers, steam, colloid mill, etc. Can use stills, condensers, etc. Reply Box 939, Modern Plastics.

PLASTICS FABRICATING PLANT located in central Ohio for sale or interested in partner who can assume active management. Present business consists of aircraft and other important industrial work. No novelty work. Reply Box 940, Modern Plastics.

TECHNICAL SALES

A large Eastern manufacturer has an excellent opening in its Plastics Department for a technical sales correspondent. The man should be between the ages of twenty-five and thirty-five and a graduate of a recognized course of training in Chemistry or Physics. Experience in technical sales work or sales correspondence would be desirable, but is not a prerequisite. The ability to handle office contacts with customers efficiently and diplomatically, however, is essential. The work at present involves products vital to the war effort, but with assured postwar markets. Further advancement depends on ability.

In replying, please give college training, employment, record of earnings, and draft status, together with a recent photograph if available. All replies will be treated in confidence. Box No. 942, Modern Plastics.

WANTED—Experienced Sales Representatives in Western New York State and in St. Louis territories, by laminated plastic manufacturer. All information furnished held confidential. The Richardson Company, Melrose Park, Illinois.

POSTWAR PRODUCTS WANTED
BY LEADING MANUFACTURER

Manufacturer with extensive engineering, manufacturing and sales facilities is desirous of acquiring newly invented or improved products with good postwar possibilities:

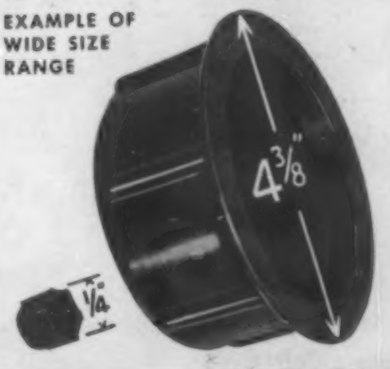
- ★ **In any stage of development**
- ★ **Cash or royalty basis**
- ★ **Direct Negotiations**
- ★ **Careful consideration and investigation of all worthwhile products**

Write stating type of product, but *do not make any confidential disclosures.* Form of agreement for making disclosures will be supplied. Address:

MODERN PLASTICS,
BOX No. 921

CONTRACT
PLASTICS MOLDING
INJECTION AND COMPRESSION MOLDING IN ALL THERMOPLASTIC AND THERMOSETTING MATERIALS

EXAMPLE OF WIDE SIZE RANGE



We have the set-up and experience to give you the best in plastics molding of small and large parts, in small or large quantities, at reasonable prices

QUOTATIONS on specific requirements without obligation

S. S. WHITE
The S. S. White Dental Mfg. Co.
PLASTICS DIVISION
Dept. M, 10 E. 40th St., New York 16, N. Y.

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